CLEAN WATER SERVICES

TIGARD, OREGON

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

DURHAM WATER RESOURCE RECOVERY FACILITY
PHASE 6B DIGESTER

VOLUME 1
SPECIFICATIONS

PROJECT NO. 7203

****

CONFORMED DOCUMENTS

****

JACOBS

Corvallis, Oregon

August 2025 [January 2026]

SECTION 00 01 07
SEALS PAGE

SPECIFICATIONS

END OF SECTION

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END OF SECTION

PART 1

PROCUREMENT REQUIREMENTS

SECTION 00030
ADVERTISEMENT FOR BIDS

Sealed Bids for construction of the Durham WRRF Phase 6B Digester Project No. 7203 (Project) will be accepted by Stephen Waldron, Procurement Specialist electronically via Equity Hubs' Bid Locker at https://bidlocker.us/details/4959 (Bid Locker) until 2:00:00 p.m., local time, on ~~October 16, 2025~~October 30, 2025[ADD. 2]. Any Bids received after the specified time will not be considered. It is each Bidder's responsibility, when submitting its Bid electronically via Bid Locker, to ensure timely delivery by submitting its Bid sufficiently in advance of the deadline. Before Bidders can submit their Bids, they will need to register with Bid Locker at https://bidlocker.us/Home/bidlockerus. There is no cost to register. First-Tier Subcontractor Disclosure Forms must be electronically submitted to Bid Locker at or before 4:00:00 p.m. local time on the same day (Deadline). If Bidder fails to submit a disclosure form with the information required by the stated Deadline, the Bid will be deemed nonresponsive and will not be considered. Clean Water Services (Owner) will not accept Bids by facsimile or email.

Bids will be publicly opened and read aloud by telephone conference at 2:00 p.m. local time on ~~October 16, 2025~~October 30, 2025[ADD. 2]. Bidders can attend the opening by calling the telephone conference number 503.681.4498.

Contractor shall complete the work as specified or indicated in Owner's Contract Documents for the Project. The Project generally consists of the following:

Furnish all labor, materials, and equipment necessary to:

a. Construct and commission a new 1.3-million gallon, cast-in-place concrete, anaerobic digester with a vertical mixer mixing system (new digester).

b. Install and commission new digester support systems including, but not limited to, a new spiral heat exchanger, hot water pump and piping, digester sludge recirculation pump and piping, grinder, and associated control valves. Install and commission new redundant digester sludge recirculation pumps for the existing Digester Complex 2 (DC2) digesters 1 and 2.

c. Construct digester gas system improvements including, but not limited to, new digester pressure relief and vacuum valves, foam separator, moisture separator, gas flow meter, isolation valves and piping associated with the new digester.

d. Construct a new access bridge from the DC2 control building to the new digester.

e. Modify the existing DC2 digesters, including, but not limited to, adding fall protection tie off anchors at roof access hatches, access modifications to the digester overflow box, replacement of existing overflow isolation slide gates with new knife gates, and installation of new digester gas isolation valves.

f. Construct improvements to the Digester Complex 1 (DC1) flare including, but not limited to, a new modulating waste gas burner (WGB) bypass valve, new regulator, new WGB electronic controller, new spark generator and panel, a new uninterruptible power supply, and new exposed and buried digester gas piping.

g. Install and commission new actuated valves for the digester feed to DC1 and DC2 in the basement of the Solids Building.

h. Install and commission a new Fats, Oils, and Grease (FOG) feed train to the new digester including a progressive cavity feed pump, flow meter, control valve, and piping from the Brown Grease Receiving Facility.

i. Install and commission two new high-efficiency, condensing natural gas boilers, boiler loop pumps, associated hot water system piping, and valve modifications.

j. Remove and replace the primary and secondary hot water system pumps, including associated hot water piping system modifications.

k. Install and commission a new hot water recirculation pump for the FOG offloading screen non-potable water hot water system.

l. Demolish the existing DC 2 electrical room air handling unit and condenser. Install and commission a new air handling unit and condenser and upsize the supply and return ductwork.

m. Site improvements including, but not limited to, a new decant facility, site lighting, drainage improvements, irrigation sleeves, topsoil and compost, asphalt roadways and curb and gutter improvements.

n. New motor control center, electrical panelboards, transformers, instrumentation, and associated conduits and conductors.

o. Upgrades to the existing electrical, instrumentation and Supervisory Control and Data Acquisition systems necessary (equipment replacement or improvements) to support the modifications.

p. Furnish and install related equipment, temporary items and systems, and other appurtenances necessary to complete the Work and to provide a complete and functional system in accordance with the Contract Documents.

The Work Site is located at Durham Water Resource Recovery Facility, 16580 SW 85th Avenue, Tigard, Oregon 97224 (Site).

The Work is a public works project subject to ORS 279C.800 to 279C.870.

The estimated construction cost of the Work is $14,580,000.

The Bidding Documents are entitled “Durham WRRF Phase 6B Digester Project No. 7203.”

All Bidding Documents and Bid Results can be downloaded from Bid Locker at https://bidlocker.us/details/4959. It is the Bidder’s responsibility to refer daily to Bid Locker’s website to check for any available amendments or addenda, response to inquiries or questions, cancellations, or notices of intent to award, and any and all information regarding this opportunity. It is not Owner’s responsibility to notify participating Bidders by email or by any other means of any of the above. Copies of this advertisement can be obtained on the Bid Locker

website or Owner's website at https://dynamic.cleanwaterservices.org/Bids. If problems are experienced downloading the Bidding Documents, please contact Stephen Waldron at 503.547.8134 or by email to waldrons@cleanwaterservices.org.

Each Bid must be submitted on the prescribed Bid Form and accompanied by Bid security as prescribed in the Instructions to Bidders. Bidders must deliver the original of the Bid security to Stephen Waldron either by first class mail to Administration Building Complex, 2550 SW Hillsboro Hwy, Hillsboro, Oregon 97123 (Owner's Office), or by hand delivery to the Durham Treatment Plant Services Building, 16060 SW 85th Avenue, Tigard, OR 97224, within five business days after the Deadline.

The Successful Bidder will be required to furnish the additional bond(s) and insurance prescribed in the Bidding Documents.

Prior to submission of its Bid, Bidder shall be registered with the Oregon Construction Contractors Board.

The Work does not involve asbestos, so the requirements of ORS 468A.700 through 468A.760 shall not apply.

Bidders must be qualified in accordance with the applicable parts of ORS 279C in order to submit a Bid for public work in Oregon.

For questions regarding technical and administrative issues, contact Owner: Stephen Waldron at 503.547.8134 or by email to waldrons@cleanwaterservices.org.

Prospective Bidders are encouraged to voluntarily attend a prebid conference and Site visit that will begin at 9:00 a.m. local time on September 23, 2025 in the Durham WRRF Operations and Maintenance Mallard Conference Center and last approximately two hours. Representatives of Owner and Engineer will be present to discuss the Project.

Owner reserves its right to reject all Bids or any Bid not conforming to the intent and purpose of the Bidding Documents.

Dated this 17th day of September, 2025.

SECTION 00100
INSTRUCTIONS TO BIDDERS

1. DEFINED TERMS

1.1. Terms used in these Instructions to Bidders and the Advertisement for Bids which are defined in the General Conditions have the meanings indicated in the General Conditions and Supplementary Conditions. Certain additional terms used in the Bidding Documents have the meanings indicated below which are applicable to both the singular and plural thereof:

1.1.1. *Owner's Office*—The office from which the Bidding Documents are to be issued and where the bidding procedures are to be administered.

1.1.2. *Bidder*—One who submits a Bid directly to Owner, as distinct from a subbidder, who submits a price or quote to a Bidder.

1.1.3. *Successful Bidde*r—Lowest, responsible and responsive Bidder to whom Owner (on the basis of Owner's evaluation as hereinafter provided) makes an award.

2. COPIES OF BIDDING DOCUMENTS

2.1. Complete sets of Bidding Documents shall be used in preparing Bids. Neither Owner nor Engineer assumes responsibility for errors or misinterpretations resulting from use of incomplete sets of Bidding Documents.

2.2. The Bidding Documents can be downloaded from the Owner's electronic procurement site, Equity Hub's Bid Locker at https://bidlocker.us/details/4959 (Bid Locker). Prospective Bidders are responsible for obtaining any amendments or addenda, response to inquiries or questions, cancellations, or notices of intent to award, and any and all information regarding this opportunity from Bid Locker. If problems are experienced downloading the Bidding Documents, please contact Stephen Waldron at 503.547.8134 or by email to waldrons@cleanwaterservices.org. Full-size Drawings may be obtained from Owner at cost of reproduction and handling, plus postage for mailing (if mailing is requested) and half-size drawings and specs are $250 per set. Drawings will only be made available to firms on the Bid Locker Plan Holders list that show they downloaded a complete set of Bidding Documents.

2.3. Owner and Engineer, in making copies of Bidding Documents available on the above terms, do so only for the purpose of obtaining Bids for the Work and do not authorize or confer a license or grant for any other use.

3. QUALIFICATIONS OF BIDDERS

3.1. To demonstrate qualifications to perform the Work, the apparent Successful Bidder and other Bidders as determined by Owner, must be prepared to submit within seven calendar days after Owner's written request, evidence such as financial data, previous experience, present commitments, and other such data as may be called for in the Bidding Documents.

3.2. Each Bid must contain evidence of Bidder's qualification to do business in the state where the Project is located or covenant to obtain such qualification prior to Contract award.

3.3. Nothing indicated herein will prejudice Owner's right to seek additional pertinent information as is provided in Article 24 – Evaluation of Bids and Award of Contract.

3.4. Bidders and every Subcontractor performing Work on the Project must have filed with the Construction Contractors Board a public works bond in the amount of $30,000 with a corporate surety authorized to do business in the State of Oregon before starting Work on the Project unless exempt under ORS 279C.836(4), (7), (8), or (9).

3.5. In order to perform public work, Bidder and its Subcontractors, prior to award of Contract or as otherwise required by the jurisdiction, shall hold or obtain such licenses as required by State Statutes, and federal and local Laws and Regulations.

3.6. Bidder is advised to carefully review those portions of the Bid Form requiring representations and certifications.

3.7. Bidder shall not be listed on the Bureau of Labor and Industries list of persons having violated prevailing wage rate laws as required in ORS 701.227.

3.8. Bidder shall not be in violation of any tax laws as required in ORS 305.385.

3.9. Bidder shall have a drug-testing program as required in ORS 279C.505.

3.10. Bidders for public work in Oregon shall be qualified in conformance with ORS Chapter 279C, in the manner designated in the Advertisement for Bids.

4. REGISTRATION REQUIREMENTS

4.1. A person, partnership, corporation, limited liability company or joint venture shall have a current, valid license issued by the Oregon Construction Contractors Board, as required by ORS chapter 701 with respect to licensing, prior to submitting a Bid to do work as a Contractor or Subcontractor. Owner may not receive or consider a Bid unless Bidder is licensed by the Construction Contractors Board.

4.2. The Project does not involve asbestos, so Contractor is not required to be licensed with the Department of Environmental Quality pursuant to ORS 468A.720.

5. EXAMINATION OF BIDDING DOCUMENTS, OTHER RELATED DATA, AND SITE

5.1. It is the responsibility of each Bidder before submitting a Bid to:

5.1.1. Examine thoroughly the Bidding Documents and other related data identified in the Bidding Documents.

5.1.2. Visit the Site and become familiar with and satisfy Bidder as to the general, local and Site conditions that may affect cost, progress, or performance of the Work.

5.1.3. Become familiar with and satisfy Bidder as to federal, state, and local Laws and Regulations that may affect cost, progress, or performance of the Work.

5.1.4. Study and carefully correlate the Bidder's observations with the Bidding Documents.

5.1.5. Carefully study all:

5.1.5.1. Reports of explorations and tests of subsurface conditions at or contiguous to the Site and all drawings of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities) that have been identified in Paragraph 5.03 of the Supplementary Conditions as containing reliable "Technical Data".

5.1.5.2. Reports and drawings of Hazardous Environmental Conditions, if any, at the Site that have been identified in Paragraph 5.06 of the Supplementary Conditions as containing reliable "Technical Data".

5.1.6. Consider the information known to Bidder; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Bidding Documents; and the Site-related reports and drawings identified in the Bidding Documents, with respect to the effect of such information, observations, and documents on:

5.1.6.1. Cost, progress, and performance of the Work.

5.1.6.2. Means, methods, techniques, sequences, and procedures of construction to be employed by Bidder, including applying any specific means, methods, techniques, sequences, and procedures of construction expressly required by the Bidding Documents.

5.1.6.3. Bidder's safety precautions and programs.

5.1.7. Agree at the time of submitting its Bid that no further examinations, investigations, explorations, tests, studies, or data are necessary for the determination of its Bid for performance of the Work at the price(s) Bid and within the times required, and in accordance with the other terms and conditions of the Bidding Documents.

5.1.8. Become aware of the general nature of the work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents.

5.1.9. Promptly notify the Engineer of all conflicts, errors, ambiguities, or discrepancies that Bidder discovers in or between the Bidding Documents and such other related data and confirm that written resolution thereof by Engineer is acceptable to Bidder.

5.1.10. Determine Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for performance of the Work.

5.2. Subsurface and Physical Conditions:

5.2.1. The Supplementary Conditions identify:

5.2.1.1. Those reports known to Owner of explorations and tests of subsurface conditions at or contiguous to the Site.

5.2.1.2. Those drawings known to Owner of physical conditions relating to existing surface and subsurface structures at the Site (except Underground Facilities).

5.2.2. Copies of reports and drawings utilized by the Engineer in the preparation of the Bidding Documents referenced will be made available by Owner to any Bidder on request at cost of reproduction and handling, plus postage for mailing (if mailing is requested), if the reports and drawings are not bound herein. Those reports and drawings are not part of the Bidding Documents, but the "Technical Data" contained therein upon which Bidder is entitled to rely as provided in Paragraph 5.03 of the General Conditions has been identified and established in Paragraph 5.03 of the Supplementary Conditions. Bidder is responsible for any interpretation or conclusion Bidder draws from any "Technical Data" or any other data, interpretations, opinions, or information contained in such reports or shown or indicated in such drawings. as provided in Paragraph 5.03 of the Supplementary Conditions, are incorporated herein by reference.

5.3. Underground Facilities: Information and data shown or indicated in the Bidding Documents with respect to existing Underground Facilities at or contiguous to the Site is based upon information and data furnished to Owner and Engineer by owners of such Underground Facilities, including Owner or others, and the Owner does not assume responsibility for the accuracy or completeness thereof unless it is expressly provided otherwise in the Supplementary Conditions.

5.4. Hazardous Environmental Condition:

5.4.1. The Supplementary Conditions identify reports and drawings known to Owner relating to a Hazardous Environmental Condition identified at the Site.

5.4.2. Copies of reports and drawings referenced will be made available by Owner to any Bidder on request. Those reports and drawings are not part of the Contract Documents, but the "Technical Data" contained therein upon which Bidder is entitled to rely as provided in Paragraph 5.06 of the General Conditions has been identified and established in Paragraph 5.06 of the Supplementary Conditions. Bidder is responsible for any interpretation or conclusion Bidder draws from any "Technical Data" or any other data, interpretations, opinions, or information contained in such reports or shown or indicated in such drawings. Costs associated with making available copies of reports and drawings shall be borne by Bidder.

5.5. Provisions concerning responsibilities for the adequacy of data furnished to prospective Bidders with respect to subsurface conditions, other physical conditions, and Underground Facilities, and possible changes in the Bidding Documents due to differing or unanticipated subsurface or physical conditions appear in Paragraph 5.03 through Paragraph 5.05 of the General Conditions. Provisions concerning responsibilities for the adequacy of data furnished to prospective Bidders with respect to a Hazardous Environmental Condition at the Site, if any, and possible changes in the Contract Documents as a result of any Hazardous Environmental Condition uncovered or revealed at the Site which was not shown or indicated on Drawings or Specifications or identified in the Contract Documents to be within the scope of the Work, appear in Paragraph 5.06 of the General Conditions.

5.6. Before submitting a Bid, each Bidder will, at Bidder's own expense, make or obtain any additional examinations, investigations, explorations, tests, and studies and obtain any additional information and data which pertain to the physical conditions (surface, subsurface, and underground facilities) at or contiguous to the Site or otherwise which may affect cost, progress, or performance of the Work and which the Bidder deems necessary to determine its Bid for performing the Work in accordance with the time, price, and other terms and conditions of the Bidding Documents.

5.7. On request, a minimum of two business days in advance, Owner will provide each Bidder access to the Site to conduct such examinations, investigations, explorations, tests, and studies as Bidder deems necessary for submission of a Bid. Location of any excavation or boring shall be subject to prior approval of Owner and applicable agencies. Bidder shall fill all holes, restore all pavement to match existing structural section, and clean up and restore the Site to its former condition upon completion of such explorations, investigations, tests, and studies. Bidder shall comply with all applicable Laws and Regulations relative to excavation and utility locates.

5.8. Related Work at Site: Reference is made to the General Requirements for identification of the general nature of other work that is to be performed at the Site by Owner or others (such as utilities and other prime contractors) that relates to the Work contemplated by these Bidding Documents. On request Owner will provide to each Bidder for examination, access to or copies of contract documents (other than portions thereof related to price) for such other work.

5.9. Safety: Paragraph 7.12 of the General Conditions indicates that if an Owner safety program exists, it will be noted in the Supplementary Conditions.

5.10. Submission of a Bid will constitute an incontrovertible representation by Bidder that Bidder has complied with every requirement of this article;

5.10.1. that without exception the Bid is premised upon performing and furnishing the Work required by Bidding Documents and applying specific means, methods, techniques, sequences, and procedures of construction that may be shown or indicated or expressly required by Bidding Documents;

5.10.2. that Bidder has given Engineer written notice of all conflicts, errors, ambiguities, and discrepancies that Bidder has discovered in Bidding Documents and the written resolutions thereof by Engineer are acceptable to Bidder; and

5.10.3. that Bidding Documents are generally sufficient in scope and detail to indicate and convey understanding of all terms and conditions for performing and furnishing the Work.

6. PREBID CONFERENCE

6.1. Prospective Bidders are encouraged to voluntarily attend a prebid conference and Site visit that will begin at 9:00 a.m. local time on September 23, 2025 in the Durham WRRF Operations and Maintenance Mallard Conference Center and last approximately two hours. Representatives of Owner and Engineer will be present to discuss the Project.

6.2. Owner will prepare and post Addenda to Bid Locker that Owner considers necessary in response to questions arising at the conference. Oral statements made by Owner's representatives may not be relied upon and will not be binding or legally effective unless confirmed by written addendum.

7. SITE AND OTHER AREAS

7.1. The lands upon which the Work is to be performed, rights-of-way, and easements for access thereto and other lands designated for use by the Contractor in performing the Work are identified in the Bidding Documents. Easements for permanent structures or permanent changes in existing facilities are to be obtained and paid for by Owner, unless otherwise provided in the Bidding Documents. All additional lands and access thereto required for temporary construction facilities, construction equipment, or storage of materials and equipment to be incorporated in the Work are to be obtained and paid for by Contractor.

8. ENVIRONMENTAL AND NATURAL RESOURCES LAWS AND REGULATIONS

8.1. Bidder's attention is directed to the Standard General Conditions of the Construction Contract (General Conditions) and Supplementary Conditions for ordinances and regulations dealing with the prevention of pollution and preservation of natural resources which may affect the performance of the Work. Bidder shall take such ordinances and regulations into consideration in preparing and submitting its Bid.

9. INTERPRETATIONS AND ADDENDA

9.1. All questions about the meaning or intent of the Bidding Documents are to be submitted to Owner via email. Additions, deletions, or revisions to the Bidding Documents considered necessary by Owner in response to such questions will be issued by Addenda and posted to Bid Locker. Questions received after ~~October 10, 2025~~October 24, 2025[ADD. 2] at 2:00 p.m. may not be answered. Only questions answered by formal written Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.

9.2. Addenda may also be issued to clarify, correct, or change the Bidding Documents as deemed advisable by Owner or Engineer. Bidders shall acknowledge receipt of all Addenda on the Bid Form in the appropriate space.

9.3. Bidders shall make no special interpretation or inference of intent from differing formats in the Technical Specifications.

10. BID SECURITY

10.1. A Bid shall be accompanied by Bid security made payable to Owner in an amount of 10 percent of Bidder's maximum Bid price and in the form of a certified or cashier's check or an approved Bid bond (on the attached form or one substantially similar to it).

10.2. The check or bond shall be given as a guarantee that the Bidder, if awarded the Work, will enter into an Agreement with Owner, and will furnish the necessary insurance certificates, Owner's Public Works Bond Information Form, Payment Bond, and Performance Bond; each of the bonds to be in the amount stated in the General Conditions and Supplementary Conditions. In case of refusal or failure to enter into the Agreement, the check or Bid Bond, as the case may be, shall be forfeited to Owner. Bid Bonds shall comply with the requirements applicable to payment and performance bonds in the General Conditions.

10.3. A copy of the original Bid security will be provided as part of the electronically submitted Bid. Bidders must deliver the original bid security to Stephen Waldron either by first class mail to Administration Building Complex, 2550 SW Hillsboro Hwy, Hillsboro, Oregon 97123 (Owner's Office) or by hand delivery to the Durham Treatment Plant Services Building, 16060 SW 85th Avenue, Tigard, OR 97224, within five business days after the Bid Deadline in the Advertisement for Bids. Write "BID SECURITY" on the face of the sealed envelope.

10.4. Within 14 calendar days after award of the Contract, Owner will return the Bid securities accompanying such Bids that are not being considered in making the award. All other Bid securities will be held until the Agreement has been finally executed. They will then be returned to the respective Bidders whose Bids they accompany.

11. CONTRACT TIMES

11.1. The number of days within which, or the dates by which, the Work is to be substantially completed and ready for final payment are set forth in the Agreement.

12. LIQUIDATED DAMAGES

12.1. Provisions for liquidated damages, if any, are set forth in the Agreement.

13. SUBSTITUTE AND "OR-EQUAL" ITEMS

13.1. The Contract, if awarded, will be on the basis of materials and equipment specified or described in the Bidding Documents without consideration of possible substitute or "or-equal" items. Whenever it is specified or described in the Bidding Documents that a substitute or "or-equal" item of material or equipment may be furnished or used by Contractor if acceptable to Engineer, application for such acceptance will not be considered by Engineer until after the Effective Date of the Agreement.

14. SUBCONTRACTORS

14.1. Oregon Revised Statutes (ORS) 279C.370 requires Bidders for public improvement projects exceeding $100,000 in Contract Price to submit a First-Tier Subcontractor Disclosure Form with their Bid, or within two working hours of Bid closing. The disclosure form must identify first-tier Subcontractors that will furnish labor or labor and materials equal to 5 percent of the Contract Price or $15,000 whichever is greater, or $350,000, regardless of percentage of

the Contract Price. If no Subcontractors are subject to the disclosure requirements, write "NONE" on the form provided in the Bidding Documents. If Bidder fails to submit a disclosure form with the dollar value and category of work information required by the stated deadline, the Bid will be considered nonresponsive and will not be considered.

14.2. For purposes of the First-Tier Subcontractor Disclosure Form, the definition of a Subcontractor does not include Suppliers who provide materials only.

14.3. If the Successful Bidder declines to make a substitution of a Subcontractor, Supplier, person, or organization acceptable to Owner, as required by Paragraph 7.06 of the General Conditions, Owner may award the Contract to the next lowest Bidder that proposes to use acceptable Subcontractors, Suppliers, and other persons and organizations. Declining to make requested substitutions will not constitute grounds for sacrificing the Bid security of any Bidder. Any Subcontractor, Supplier, other person, or organization listed and to whom Owner or Engineer does not make written objection prior to giving the Notice of Award will be deemed acceptable to Owner and Engineer subject to revocation of such acceptance after the effective date of the Agreement as provided in Paragraph 7.06 of the General Conditions.

15. WAGE RATES/BOLI FEE

15.1. The Work under these Bidding Documents is to be paid for by public funds. This is a public works project subject to the state prevailing rates of wage under ORS 279C.800 to 279C.870. Unless otherwise exempt, Contractor and any Subcontractors must pay workers in each trade or occupation that Contractor or its Subcontractors or other person who is a party to the Contract uses in performing all or a part of the Contract not less than the applicable minimum Oregon prevailing wage rates in accordance with ORS 279C.838 and ORS 279C.840. The applicable Oregon minimum prevailing wage rates for such workers are contained in the publication *Prevailing Wages Rates for Public Works Contracts* dated July 5, 2025 (see link titled "*July 5, 2025, Prevailing Wage Rate Book*" at https://www.oregon.gov/boli/employers/Pages/prevailing-wage-rates.aspx), available at http://www.oregon.gov/boli and are hereby incorporated herein as of the date these Bidding Documents were first advertised.

15.2. ORS 279C.365(1)(g) requires that all Bids for public work, including those public work projects financed by federal funds and subject to the Davis Bacon Act, shall include a statement by the Bidder that it will comply with the provisions of ORS 279C.838, 279C.840 or 40 U.S.C. Section 3141 et seq. When the Bid Form in the Bidding Documents contains a statement of Bidder's declaration of compliance with ORS 279C.838, 279C.840 or 40 U.S.C. Section 3141 et seq., the Bidder's signing of the Bid constitutes compliance with this Oregon Statute.

15.3. Owner shall be responsible for paying the fee required by ORS 279C.825(1) to the Commissioner of the Bureau of Labor and Industries.

15.4. ORS 279C.836 requires that, before starting work on a contract or subcontract for a public works project, Contractor or Subcontractor shall file with the Construction Contractors Board a public works bond with the corporate surety authorized to do business in the State of Oregon in the amount of $30,000.

16. PREPARATION OF BID FORM

16.1. The Bid shall be submitted on the Bid Forms provided herein. No substitution of the Bid Form will be allowed.

16.2. All blanks on the Bid Form shall be completed by typing or printing with ink and the Bid Form signed in ink. Erasures or alterations shall be initialed in ink by the person signing the Bid Form.

16.3. A Bid by a corporation shall be executed in the corporate name by the president or a vice president or other corporate officer accompanied by enclosed Bid Certificate. The corporate seal shall be affixed and attested by the secretary or an assistant secretary. The corporate address and state of incorporation shall be shown.

16.4. A Bid by a partnership shall be executed in the partnership name and signed by a partner (whose title must appear under the signature), accompanied by enclosed Bid Certificate. The official address of the partnership shall be shown.

16.5. A Bid by a limited liability company (LLC) shall be executed in the name of the LLC and be signed by a manager if the LLC is manager managed or a member if the LLC is member managed, accompanied by the enclosed Bid Certificate. The state of formation of the firm and the official address of the LLC shall be shown.

16.6. A Bid by a joint venture shall be executed in the joint venture name and be signed by a joint venture managing partner, accompanied by the enclosed Bid Certificate, and his/her title must appear under the signature. The official address of the joint venture shall be shown.

16.7. All names shall be typed or printed in ink below the signatures.

16.8. The Bid shall contain an acknowledgement of receipt of all Addenda; the numbers of which shall be filled in on the Bid Form.

16.9. Postal and e-mail addresses and telephone number for communications regarding the Bid shall be shown.

16.10. Owner will consider the signatures on the Bid Forms as electronic signatures.

16.11. Submit the completed Bid Forms and the copy of the Bid Security as one PDF file to Bid Locker at https://bidlocker.us/details/4959.

17. TRADE SECRET/CONFIDENTIAL

17.1 Any information Bidder submits in response to the Invitation to Bid (ITB) that Bidder considers a trade secret under ORS 192.345(2) or confidential proprietary information, and that Bidder wishes to protect from public disclosure, must be clearly labeled with the following: "This information constitutes a trade secret under ORS 192.345(2) or confidential proprietary information, and is not to be disclosed except in accordance with the Oregon Public Records Law, ORS chapter 192." Bidders are cautioned that price information submitted in response to an ITB is generally not considered a trade secret under the Oregon Public Records Law. Further, information submitted by Bidders that is already in the public domain is not protected. Owner shall not be liable for disclosure or release of information when authorized or required by law or

court order to do so. Owner shall also be immune from liability for disclosure or release of information under the circumstances set out in ORS 646.473(3).

18. BASIS OF BID; COMPARISON OF BIDS

18.1. The Bid will be compared and the basis for award will be set forth on the Bid Form.

19. SUBMISSION OF BID

19.1. The Bid Forms are to be completed and submitted with the Bid security and the following:

19.1.1. First-Tier Subcontractor Disclosure Forms must be included with the Bid or electronically submitted to the Bid Locker within two hours of the specified time for receipt of Bids.

19.1.2. Bidder's state Contractor license number for the State of Oregon shall be shown on the Resident/Nonresident Bidder Status/Construction Contractor's Licensing and Public Works Bond Form.

19.2. The Bid shall be delivered by the time and to the place stipulated in the Advertisement for Bids. It is the Bidder's sole responsibility to see that its Bid is received in proper time and at the proper place.

19.3. The Bid shall be submitted to Bid Locker following the instructions available on the Bid Locker site by the date and hour of the opening of Bids. Oral, telegraphic, or telephonic Bids or modifications will not be considered.

20. MODIFICATIONS AND UNAUTHORIZED ALTERNATIVE BIDS

20.1. Unauthorized conditions, limitations, or provisos attached to the Bid shall render it informal and may cause its rejection as being nonresponsive. The Bid Forms shall be completed without interlineations, alterations, or erasures in the printed text. Alternative Bids will not be considered unless called for.

21. MODIFICATION AND WITHDRAWAL OF BID

21.1. If you submitted your bid to Bid Locker, you may withdraw your bid and revise and resubmit it up until the Bid Deadline.

21.2. If within 24 hours after Bids are opened any Bidder files a duly signed written notice with Owner and promptly thereafter demonstrates to the reasonable satisfaction of Owner that there was a material and substantial mistake in the preparation of its Bid, as determined by Oregon law and any applicable Owner's Purchasing Rules, that Bidder may withdraw its Bid, and the Bid security will be returned. Thereafter, if the Work is rebid, that Bidder will be disqualified from further bidding on the Work.

22. OPENING OF BIDS

22.1. Bids will be opened at the time and place indicated in the Advertisement for Bids and unless obviously nonresponsive, read aloud publicly by telephone conference. An abstract of the

amounts of the base Bids and major alternates, if any, will be posted to Bid Locker for Bidders after the opening of Bids.

23. BIDS TO REMAIN SUBJECT TO ACCEPTANCE

23.1. All Bids will remain subject to acceptance for the period of time stated in the Bid Forms, but Owner may, in its sole discretion, release any Bid and return the Bid security prior to the end of this period.

24. EVALUATION OF BIDS AND AWARD OF CONTRACT

24.1. Nonresident Bidders: In determining the lowest responsible Bidder, Owner will for the purpose of awarding the Contract, add a percent increase on the Bid of a nonresident Bidder equal to the percent, if any, of the preference given to that Bidder in the state in which the Bidder resides.

24.2. Owner reserves the right to reject any or all Bids, including without limitation, nonconforming, nonresponsive, unbalanced or conditional Bids and may cancel the procurement. Owner further reserves the right to reject the Bid of any Bidder whom it finds, after reasonable inquiry and evaluation, to not be responsible. Owner may also reject for good cause all Bids upon a finding by Owner that it is the public interest to do so. Owner also reserves the right to waive all informalities not involving price, time, or changes in the Work. No changes to the Contract Documents will be allowed. Submission of a Bid constitutes acceptance of the terms of the Contract Documents.

24.3. More than one Bid from an individual, firm, partnership, corporation, LLC or association under the same or different names will not be considered. If Owner believes that any Bidder is interested in more than one Bid for the Work contemplated, all Bids in which such Bidder is interested will be rejected. If Owner believes that collusion exists among the Bidders, all Bids will be rejected. A party who has quoted prices to a Bidder is not hereby disqualified from quoting prices to other Bidders, or from submitting a Bid directly for the Work.

24.4. In evaluating Bids, Owner will consider whether or not the Bids comply with the prescribed requirements, and such alternates, unit prices, and other data, as may be requested in the Bid Forms or prior to the Notice of Award.

24.5. Discrepancies in Bids. In the event there is more than one Bid item in a Bid Schedule, the Bidder shall furnish a price for all Bid items in the Schedule, and failure to do so will render the Bid non-responsive and will cause its rejection. In the event there are unit price Bid items in a Bidding Schedule and the amount indicated for a unit price Bid item does not equal the product of the unit price and quantity, the unit price shall govern and the amount will be corrected accordingly, and the Bidder shall be bound by the correction. In the event there is more than one Bid item in a Bid Schedule and the total indicated for the Schedule does not agree with the sum of the prices bid on the individual items, the prices bid on the individual items shall govern and the total for the Schedule will be corrected accordingly, and the Bidder shall be bound by the correction. In the case of discrepancies between figures and written words, words shall govern.

24.6. In evaluating Bidders, Owner may consider the qualifications of Bidders and may consider the qualifications and experience of Subcontractors, Suppliers, and other individuals or entities proposed for those portions of the Work for which the identity of Subcontractors,

Suppliers, and other individuals or entities must be submitted either with the Bid, or otherwise prior to issuance of the Notice of Award.

24.7. Owner may conduct such investigations as Owner deems necessary to assist in Bid evaluation and to establish responsibility, qualifications, and financial ability of Bidders, proposed Subcontractors, Suppliers, individuals, or entities proposed for those portions of the Work in accordance with the Bidding Documents to Owner's satisfaction within the prescribed time.

24.8. Owner may consider the operating costs, maintenance requirements, performance data, and guarantees of major items of materials and equipment proposed for incorporation in the Work when such data are required to be submitted prior to the Notice of Award. The evaluation criteria will be set forth on the Bid Forms.

24.9. If, at the time this Contract is to be awarded, the total of the lowest acceptable Bid exceeds the funds then estimated by Owner as available, Owner may reject all Bids or take such other action as best serves Owner's interests.

24.10. In the event of failure of the Successful Bidder to sign the Agreement and provide acceptable Performance and Payment Bond(s), insurance certificate(s), and other required documents, Owner may award the Contract to the next lowest responsive, responsible Bidder.

24.11. Award of the Contract, if awarded, will be made to the lowest responsive, responsible Bidder whose Bid complies with the requirements of the Bidding Documents. Unless otherwise specified, any such award will be made within the period stated in the Advertisement for Bids that the Bids are to remain open. Unless otherwise indicated, a single award will be made for all the Bid items in an individual Bid Schedule. In the event the Work is contained in more than one Bid Schedule, Owner will award all Schedules.

25. CONTRACT SECURITY AND INSURANCE

25.1. Article 6 of the General Conditions, as may be modified by the Supplementary Conditions, sets forth Owner's requirements as to bonds and insurance. When the Successful Bidder delivers an executed Agreement to Owner, it shall be accompanied by such bonds.

26. SIGNING OF AGREEMENT

26.1. When Owner issues a Notice of Award to the Successful Bidder, it will also provide electronic access to a copy of the of unsigned counterparts of the Agreement along with the other Contract Documents that are identified in the Agreement and attached thereto. Owner would like to obtain electronic signatures on the Agreement using DocuSign. Within 30 days thereafter, the Successful Bidder will submit to Owner original paper copies of insurance certificates and Performance and Payment Bonds. Within 10 days of receipt of acceptable bonds and insurance certificates, Owner will electronically send the Successful Bidder the Agreement to sign, and once signed by all parties, will provide the Successful Bidder electronic access to one fully-signed Agreement that includes a complete set of Drawings with appropriate identification.

26.2. The Bidder to whom award is made shall electronically execute the Agreement with Owner on the form of agreement provided, shall secure all insurance, and shall furnish all

certificates and bonds required by the Bidding Documents within the time period set forth in Section 26.1. Failure or refusal to enter into an Agreement as herein provided or to conform to any of the stipulated requirements in connection therewith shall be just cause for annulment of the award, forfeiture of the Bid security, and liability for other damages. If the lowest responsive, responsible Bidder refuses or fails to execute the Agreement, Owner may award the Contract to the second lowest responsive, responsible Bidder. If the second lowest responsive, responsible Bidder refuses or fails to execute the Agreement, Owner may award the Contract to the third lowest responsive, responsible Bidder. On the failure or refusal of such second or third lowest Bidder to execute the Agreement, each such Bidder's Bid securities shall be likewise forfeited to Owner.

27. RETAINAGE

27.1. Provisions concerning retainage and Contractor's rights to deposit securities in lieu of retainage, if applicable, are set forth in the Agreement.

28. CONTRACTS TO BE ASSIGNED

28.1. Not Applicable.

29. PROTEST PROCEDURE.

29.1. Owner has adopted its own public contracting rules and is not subject to the Attorney General's Model Public Contracting Rules. Owner's rules have opportunities for Bidders to protest at various stages in the procurement process. This section only contains a brief summary of the deadlines, conditions required to file a protest and the information required to be included in a protest. Copies of Owner's rules containing the protest process may be obtained by contacting Owner's representative, Stephen Waldron by email to waldrons@cleanwaterservices.org or by first-class mail to Owner's Office.

29.2. Specification Protest Process. Under Owner's rules, Prospective Bidders must submit a written protest of the Specifications to Owner. The written protest must:

29.2.1. Be delivered to Stephen Waldron, by email to waldrons@cleanwaterservices.org or first class mail to Owner's Office.

29.2.2. Reference the title of the Bidding Documents.

29.2.3. Identify the prospective Bidder's name and contact information.

29.2.4. Be signed by an authorized representative.

29.2.5. State the reason or the grounds for the protest, including;

29.2.5.1. A detailed statement of the legal and factual grounds for the request or protest;

29.2.5.2. A description of the resulting prejudice to the Bidder; and

29.2.5.3. A statement of the form of relief requested or any proposed changes to the Specifications.

29.2.6. Be received by Stephen Waldron within ten calendar days prior to the due date for Bids. Owner shall not consider a prospective Bidder's protest if it is submitted after the established time period.

29.3. Solicitation Protest. Under Owner's rules, prospective Bidders may submit a written protest of anything contained in the Bidding Documents, including but not limited to the Invitation to Bid process, Scope of Work and the Contract Documents. Should a Bidder find discrepancies in, or omissions from the Bidding Documents, or should the Bidder be in doubt as to their meaning, or believes that any aspect of the Bidding Documents is improvident or unlawful, or which may unnecessarily restrict competition, the Bidder should at once notify Owner in the form of a protest. This is a prospective Bidder's only opportunity to protest the provisions of the Bidding Documents. The purpose of this protest procedure is to permit Owner time to correct, prior to the submission of Bids, aspects of the Bidding Documents that may be improvident or unlawful, or which may unnecessarily restrict competition. This requirement is intended to eliminate, by permitting corrections prior to the submission of Bids, the waste of resources and delay that may result from the untimely detection of errors in the Bidding Documents, possible protests, and possible rejection of Bids. Failure to file a protest by the time and date indicated below will be deemed a waiver of any claim by a Bidder that the selection process is improvident or unlawful, or which may unnecessarily restrict competition. The written protest must:

29.3.1. Be delivered to Stephen Waldron, by email to waldrons@cleanwaterservices.org or first class mail to Owner's Office.

29.3.2. Reference the title of the Bidding Documents.

29.3.3. Identify the prospective Bidder's name and contact information.

29.3.4. Be signed by an authorized representative.

29.3.5. State the reason or the grounds for the protest, including:

29.3.5.1. The grounds that demonstrate how the procurement process is contrary to law or unnecessarily restrictive, is legally flawed or improperly specifies a brand name;

29.3.5.2. Evidence or documentation that supports the grounds on which the protest is based; and

29.3.5.3. Relief sought.

29.3.6. State the desired changes to the procurement process or the Bidding Document provisions that the prospective Bidder believes will remedy the conditions that were the basis of the protest.

29.3.7. Be received by Stephen Waldron within ten calendar days prior to the due date for Bids. Owner shall not consider a prospective Bidder's protest if it is submitted after the established time period.

29.4. Award Protest. Affected or aggrieved Bidders will also have an opportunity to protest Owner's Notice of Award that Owner will post under the title of the Bidding Documents Durham WRRF Phase 6B Digester, Project No. 7203 on Bid Locker. A Bidder is adversely affected or aggrieved only if the bidder is eligible for award of the Contract as the responsible Bidder submitting the lowest responsive Bid and is next in line for award, i.e., the protesting Bidder must claim that all lower bidders are ineligible for award. The written protest must:

29.4.1. Be delivered to Stephen Waldron, by email to waldrons@cleanwaterservices.org or first class mail to Owner's Office.

29.4.2. Reference the title of the Bidding Documents.

29.4.3. Identify the prospective bidder's name and contact information.

29.4.4. Be signed by an authorized representative.

29.4.5. Specify the grounds for the protest.

29.4.6. Be received by Stephen Waldron within seven calendar days after issuance of Owner's Notice of Award.

29.5. At the request of the protester, a hearing may be conducted before Owner's staff within seven calendar days after submission of the written protest. Owner will either uphold or deny the protest, and a written response will be issued for all properly submitted protests. However, any response by Owner is not intended as, and shall not in and of itself constitute, confirmation that the Bidder is, in fact, adversely affected or aggrieved, and therefore entitled to protest an award, or that the protest was timely or properly submitted. After expiration of the protest period and resolution of any protests, Owner will proceed with final award of the Contract.

29.6. Owner shall not consider a Bidder's protest if it is submitted after the established time period. A Bidder must exhaust all administrative remedies before seeking judicial review of Owner's contractor selection or Contract award decision.

29.7. Award decision. The award by Owner, or if required by Owner's Board of Directors of a Contract shall constitute a final decision of the Owner to award a Contract if no written protest of the award is filed.

END OF SECTION

SECTION 00300
BID FORMS

BID TO: Clean Water Services:

1. The undersigned Bidder proposes and agrees, if this Bid is accepted, to enter into an Agreement with Owner in the form included in the Bidding Documents to perform all Work as specified or indicated in the Bidding Documents entitled Durham WRRF Phase 6B Digester Project No. 7203 for the prices and within the times indicated in this Bid and in accordance with the other terms and conditions of the Bidding Documents.

2. Bidder accepts all of the terms and conditions of the Bidding Documents, Contract Documents, including without limitation those in the Advertisement for Bids and Instructions to Bidders, dealing with the disposition of the Bid security.

3. This Bid will remain open for 60 calendar days from the Bid due date unless otherwise required by law or for such longer period of time that Bidder may agree to in writing upon request of Owner. Bidder will enter into an Agreement within the time and in the manner required in the Advertisement for Bids and the Instructions to Bidders, and will furnish the insurance certificates, Payment Bond and, Performance Bonds required by the Contract Documents, and Owner's Subcontractor Public Works Bond Information Form.

4. BIDDER'S REPRESENTATIONS

4.1. In submitting this Bid, Bidder represents that:

4.1.1. Bidder has examined and carefully studied the Bidding Documents, the other related data identified in the Bidding Documents, and the following Addenda, receipt of which is hereby acknowledged.

Addendum No.	Addendum Date

(Bidder shall insert the number of each Addendum received.)

Failure to acknowledge receipt of Addenda may render the Bid non-responsive and may be cause for its rejection.

4.1.2. Bidder has familiarized itself with the nature and extent of the Contract Documents, Work, Site, locality where the Work is to be performed, the legal requirements (federal, state and local laws, ordinances, rules, and regulations), and the conditions affecting cost, progress or performance of the Work and has made such independent investigations as Bidder deems necessary.

4.1.3. Bidder has visited the Site (or was offered the opportunity to visit) and become familiar with and is satisfied as to the general, local, and Site conditions that may affect cost, progress, and performance of the Work.

4.1.4. Bidder is familiar with and is satisfied as to all Laws and Regulations that may affect cost, progress, and performance of the Work.

4.1.5. Bidder has carefully studied: i) reports of explorations and tests of subsurface conditions at or contiguous to the Site and drawings of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities) which have been identified in Paragraph 5.03 of the Supplementary Conditions as containing reliable "Technical Data,"; and ii) reports and drawings of Hazardous Environmental Conditions, if any, at the Site that have been identified in Paragraph 5.06 of the Supplementary Conditions as containing reliable "Technical Data."

4.1.6. Bidder has considered the information known to Bidder; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Bidding Documents; and the Site-related reports and drawings identified in the Bidding Documents, with respect to the effect of such information, observations, and documents on (1) the cost, progress, schedule duration, and performance of the Work; (2) the means, methods, techniques, sequences, and procedures of construction to be employed by Bidder, including applying the specific means, methods, techniques, sequences, and procedures of construction expressly required by the Bidding Documents; and (3) Bidder's safety precautions and programs.

4.1.7. Based on information and observations referred to in paragraph above, Bidder does not consider that further examinations, investigations, explorations, tests, studies, or data are necessary for the determination of this Bid for performance of the Work at the price(s) Bid and within the times required, and in accordance with the other terms and conditions of the Bidding Documents.

4.1.8. Bidder is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents.

4.1.9. Bidder has given Engineer written notice of conflicts, errors, ambiguities, or discrepancies that Bidder has discovered in the Bidding Documents, and the written resolution thereof by Engineer is acceptable to Bidder.

4.1.10. The Bidding Documents are generally sufficient to indicate and convey understanding of terms and conditions for the performance of the Work for which this Bid is submitted.

5. BIDDER'S CERTIFICATION

5.1. Bidder certifies:

5.1.1. This Bid is genuine and not made in the interest of or on behalf of any undisclosed individual or entity and is not submitted in conformity with any collusive agreement or rules of any group, association, organization or corporation.

5.1.2. Bidder has not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid.

5.1.3. Bidder has not solicited or induced any individual or entity to refrain from bidding.

5.1.4. Bidder has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for the Agreement. For the purposes of this paragraph:

5.1.4.1. "corrupt practice" means the offering, giving, receiving, or soliciting of anything of value likely to influence the action of a public official in the bidding process;

5.1.4.2. "fraudulent practice" means an intentional misrepresentation of facts made (a) to influence the bidding process to the detriment of Owner, (b) to establish Bid prices at artificial noncompetitive levels, or (c) to deprive Owner of the benefits of free and open competition;

5.1.4.3. "collusive practice" means a scheme or arrangement between two or more Bidders, with or without the knowledge of Owner, a purpose of which is to establish Bid prices at artificial, noncompetitive levels; and

5.1.4.4. "coercive practice" means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the bidding process or affect the execution of the Agreement.

5.1.5. Owner is tax exempt. Required corporate activity, sales and use and all other taxes are included in the stated Bid prices for the Work.

5.1.6. Bidder will be bound by and comply with all of the applicable requirements of ORS 279C.800 to 279C.870 and the administrative rules of the Bureau of Labor and Industries (BOLI) regarding prevailing wage rates and will pay prevailing wage rates in accordance with 279C.840.

5.1.7. Neither Bidder nor its Subcontractors are on the BOLI list of persons having violated prevailing wage rate laws.

5.1.8. Bidder has not discriminated and will not discriminate, in violation of ORS 279A.110(1) against any disadvantaged business enterprise, a minority-owned business, woman-owned business, a business that a service-disabled veteran owns or an emerging small business that is certified under ORS 200.055, in awarding a required subcontract.

5.1.9. Bidder is not in violation of any tax laws described in ORS 305.385.

5.1.10. Bidder has established a drug-testing program for employees per ORS 279C.505 and that Bidder, if awarded the Agreement, will at the time of Agreement award represent and warrant to Owner that its employee drug-testing program remains in place and will continue in full force and effect for the duration of the Agreement.

5.1.11. Subcontractors performing work will be registered with the Construction Contractors Board before Subcontractor commences work.

5.1.12. Bidder shall comply with the prohibitions set forth in ORS 652.220 prohibiting discriminatory wage rates based upon an employee's membership in a protected class and acknowledges that compliance is a material element of the Agreement and failure to comply is a breach that entitles Owner to terminate the Agreement for cause.

5.1.13. Bidder's information contained in the Resident/Nonresident Bidder Status, Construction Contractor's Licensing and Public Works Bond Information sections is true and correct.

5.1.14. Owner shall not be liable for any expenses incurred by Bidder or any other person or entity in preparing or submitting its Bid or in participating in the Bid evaluation/selection process. Each Bidder who prepares and submits a bid in response to this solicitation does so solely at the Bidder's own cost and expense.

6. BASIS OF BIDS

6.1. Bidder shall complete the Work in accordance with the Contract Documents for the price(s) described in the attached Bid Schedule.

7. TIME OF COMPLETION

7.1. Bidder agrees to complete the Work within the Contract Times stipulated in the Agreement and accepts the provisions of the Agreement as to liquidated damages in the event of failure to complete the Work, and any specified Milestones, within the Contract Times.

8. ATTACHMENTS TO THIS BID

8.1. The following documents are submitted with and made a condition of this Bid:

Bid Schedule
Bid Certificate
Bid Bond
Resident/Nonresident Bidder Status /Construction Contractor's Licensing and Public Works Bond Form
First-Tier Subcontractor Disclosure Form

To all the foregoing, and including all Bid Forms contained in this Bid, the Bidder further agrees to complete the Work required under the Contract Documents within the Contract Time stipulated in the Contract Documents, and to accept in full payment therefore the Contract Price based on the Base Bid Price named in the Bid Forms.

Dated: _____ Bidder: _____

By: _____
Name (Signature)

_____
Name (Type or Print)

Title: _____

BID SCHEDULE

Schedule of Bid Prices for
DURHAM WRRF PHASE 6B DIGESTER,
PROJECT NO. 7203

1. LUMP SUM WORK

1.1. Bidder proposes and agrees to accept as full payment the following bid amount for the Durham WRRF Phase 6B Digester Project No. 7203 proposed within the Bidding Documents, and certifies that this amount is based upon the undersigned's own estimate of quantities and costs and includes sales, consumer, use, tariffs and other import duties, Oregon Corporate Activity Tax and all other taxes, and overhead and profit. **Lump Sum Bid Price equals the price of the lump sum work plus the sum of all 'A'-listed Major Equipment Option Prices from Section 3.** Insert the Lump Sum Bid Price into Section 1.2 below.

1.2. Lump Sum Bid Price: $_____

2. UNIT PRICE BID SCHEDULE:

2.1. Unit prices have been computed in accordance with Paragraph 13.03.C of the General Conditions.

2.2. Bidder acknowledges that estimated quantities are not guaranteed, and are solely for the purpose of comparison of Bids, and final payment for all unit price Bid items will be based on actual quantities, determined as provided in the Contract Documents.

2.3. The extended bid unit price is arrived at by multiplying the bid unit price by the estimated quantity.

Unit Price Bid Schedule					
Item No.	Description	Estimated Quantity	Unit	Bid Unit Price	Extended Bid Unit Price
1.	Secant Pile Excavation Support System Mobilization	Lump Sum	Lump Sum		
2.	Secant Pile Excavation Support System Materials and Installation	9,700 (Note 1)	Square feet		
3.	Secant Pile Excavation Support System Demobilization	Lump Sum	Lump Sum		
				Total of Extended Bid Unit Prices	$

Unit Price Bid Schedule Notes:

1. The estimated quantity (interior, square foot area) is based on installing a secant pile excavation support system around the entire perimeter (360 degrees) of the new digester to the approximate depth shown on Drawings 005-CX-101 and 005-CX-301. The secant pile excavation support system is Contractor designed to meet the requirements specified in Section 02265, Secant Pile Excavation Support System.

3. MAJOR EQUIPMENT OPTIONS PRICE SCHEDULES

Bidder further agrees to accept as full payment for furnishing the items listed below, and any Work necessary to install the items, for the prices included in the "Option Price" column for each item. Additional instructions for the Bidders are as follows:

3.1. The Option Price shall include the quantity in the Bidding Documents and all associated requirements identified in the specification sections listed below as the responsibility of the contractor, equipment manufacturer and/or supplier.

3.2. The Bidder shall provide a price for the 'A'-listed manufacturer.

3.3. If Owner selects an option other than an 'A'-listed manufacturer, the lump sum bid price will be modified by change order after Contract award.

3.4. Include in the Option Price for each Bidder-proposed option, the cost of Work, redesign and construction changes, including, but not limited to, electrical, mechanical, structural, and any other modifications to the Work necessary to make the several parts fit together and perform as specified.

3.5. Bidder may propose an "or equal" option for the 'A'-listed Major Equipment where indicated by including the Manufacturer's name for items where a blank has been provided.

3.6. Any schedule delays caused by Owner's selection of an option other than the option included in the Base Bid Price will not constitute grounds for an adjustment to the Contract time or Contract price.

Major Equipment Options Schedule		
Progressive Cavity Pumps (Specification No. 11315)		
Option	Manufacturer or Supplier	Option Price
A	Seepex	$
B		$

Major Equipment Options Schedule		
Digester Mixer (Specification No. 11385)		
Option	Manufacturer or Supplier	Option Price
A	SPX Flow, Lightnin	$
B		$

Major Equipment Options Schedule		
Heating Boilers (Specification No. 15500)		
Option	Manufacturer or Supplier	Option Price
A	Cleaver Brooks	$
B		$

Major Equipment Options Schedule		
Flow Measurement: Thermal Mass (Specification No. 17305)		
Option	Manufacturer or Supplier	Option Price
A	Fluid Component Inc. (FCI)	$
B		$

Major Equipment Options Schedule		
Flow Measurement: Ultrasonic Time of Flight Flowmeter (Specification No. 17310)		
Option	Manufacturer or Supplier	Option Price
A	Flexim	$
B		$

Major Equipment Options Schedule		
Flow Measurement: Ultrasonic Doppler Flowmeters (Specification No. 17311)		
Option	Manufacturer or Supplier	Option Price
A	Pulsar	$
B		$

4. BASE BID SUMMARY

4.1. Insert the sum equal to the **Lump Sum Bid Price** from Section 1 plus the **Total Extended Bid Unit Prices** from Section 2 into the **Base Bid Price (Basis of Award)** blank provided below.

4.2. Owner will award the Agreement to the lowest responsive, responsible Bidder submitting the lowest Base Bid Price. **Base Bid Price (Basis of Award)** = **Lump Sum Bid Price** from Section 1 (Lump Sum Bid Price = price of lump sum work + sum of all 'A'-listed Major Equipment Option Prices from Section 3) + **Total Extended Bid Unit Prices** from Section 2.

BASE BID PRICE (BASIS OF AWARD)

$_____
(figures)

_____
(words)
(The amount in words takes precedence.)

BID CERTIFICATE
(if Corporation)

STATE OF _____)
) ss:
COUNTY OF_____)

I HEREBY CERTIFY that a meeting of the Board of Directors of _____

_____

_____,

a corporation existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____ as _____ of this Corporation, be and is hereby authorized to execute the Bid for Durham WRRF Phase 6B Digester Project No. 7203 dated _____ to Clean Water Services by this Corporation and that his/her execution thereof, attested by the Secretary of this Corporation shall be the official act and deed of this Corporation."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____ day of _____, 20___.

_____
(Signature)

_____
(Title)

Attested by:

_____
Secretary

_____

_____
(Address)

BID CERTIFICATE
(if Partnership)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Partners of _____

_____

_____,

a partnership existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____, as _____ of the Partnership, be and is hereby authorized to execute the Bid for Durham WRRF Phase 6B Digester Project No. 7203 dated _____ to Clean Water Services by this Partnership and that his/her execution thereof, attested by the General Partner shall be the official act and deed of this Partnership."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____ day of _____, 20___.

_____
(Signature)

_____
(Title)

Attested by:

_____
General Partner

_____

_____
(Address)

BID CERTIFICATE
(if Limited Liability Company)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Members or Managers of

_____,
(Insert Limited Liability Company Name Here)

a limited liability company existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that_____, as _____ of this limited liability company, be and is hereby authorized to execute the Bid for Durham WRRF Phase 6B Digester Project No. 7203 dated _____ to Clean Water Services by this limited liability company and that his/her execution thereof, attested by _____ of this limited liability company shall be the official act and deed of this limited liability company."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____ day of _____, 20___.

By:_____
(Signature)

_____
(Title)

Attested by:

_____
(Signature)

_____
(Address)

BID CERTIFICATE
(if Joint Venture)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Principals of _____

_____

_____,

a joint venture existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____, as _____ of the Joint Venture, be and is hereby authorized to execute the Bid for Durham WRRF Phase 6B Digester Project No. 7203 dated _____ to Clean Water Services by this Joint Venture and that his/her execution thereof, attested by the _____ shall be the official act and deed of this Joint Venture."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____ day of _____ _____, 20___.

_____
Managing Partner

Attested by:

_____
(Signature)

_____

_____
(Address)

BID BOND

Any singular reference to Bidder, Surety, Owner, or other party shall be considered plural where applicable.
BIDDER (Name and Address):

SURETY (Name and Address of Principal Place of Business):

OWNER:
Clean Water Services, 2550 SW Hillsboro Hwy, Hillsboro, OR 97123

BID
Bid Due Date:
Project (Brief Description Including Location): Durham WRRF Phase 6B Digester, Project No. 7203
Durham Water Resource Recovery Facility, 16580 SW 85th Avenue, Tigard, Oregon 97224

BOND
Bond Number:
Date (Not later than Bid due date):

Penal sum _____
(Words)

_____
(Figures)

Surety and Bidder, intending to be legally bound hereby, subject to the terms of this Bid Bond, do each cause this Bid Bond to be duly executed on its behalf by its authorized officer, agent, or representative.

BIDDER	SURETY
(Seal)	(Seal)
Bidder's Name and Corporate Seal	Surety's Name and Corporate Seal
By: _____	By: _____
Signature	Signature
_____	_____
Title	Title (Attach Power of Attorney)
Attest: _____	Attest: _____
Signature	Signature
_____	_____
Title	Title

Note: Above addresses are to be used for giving required notice.

1. Bidder and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors, and assigns to pay to Owner upon default of Bidder the penal sum set forth on the face of this Bond. Payment of the penal sum is the extent of Surety's liability.

2. Default of Bidder shall occur upon the failure of Bidder to deliver within the time required by the Bidding Documents (or any extension thereof agreed to in writing by Owner) the executed Agreement required by the Bidding Documents and any performance and payment bonds required by the Bidding Documents.

3. This obligation shall be null and void if:

3.1. Owner accepts Bidder's Bid and Bidder delivers within the time required by the Bidding Documents (or any extension thereof agreed to in writing by Owner) the executed Agreement required by the Bidding Documents and any performance and payment bonds required by the Bidding Documents, or

3.2. All Bids are rejected by Owner, or

3.3. Owner fails to issue a Notice of Award to Bidder within the time specified in the Bidding Documents (or any extension thereof agreed to in writing by Bidder and, if applicable, consented to by Surety when required by Paragraph 5 hereof).

4. Payment under this Bond will be due and payable upon default by Bidder and within 30 calendar days after receipt by Bidder and Surety of written notice of default from Owner, which notice will be given with reasonable promptness, identifying this Bond and the Project and including a statement of the amount due.

5. Surety waives notice of any and all defenses based on or arising out of any time extension to issue Notice of Award agreed to in writing by Owner and Bidder, provided that the total time for issuing Notice of Award including extensions shall not in the aggregate exceed 120 days from Bid due date without Surety's written consent.

6. No suit or action shall be commenced under this Bond prior to 30 calendar days after the notice of default required in Paragraph 4 above is received by Bidder and Surety and in no case later than one year after Bid due date.

7. Any suit or action under this Bond shall be commenced only in a court of competent jurisdiction located in the state in which the Project is located.

8. Notices required hereunder shall be in writing and sent to Bidder and Surety at their respective addresses shown on the face of this Bond. Such notices may be sent by personal delivery, commercial courier, or by United States Registered or Certified Mail, return receipt requested, postage pre-paid, and shall be deemed to be effective upon receipt by the party concerned.

9. Surety shall cause to be attached to this Bond a current and effective Power of Attorney evidencing the authority of the officer, agent, or representative who executed this Bond on behalf of Surety to execute, seal, and deliver such Bond and bind the Surety thereby.

10. This Bond is intended to conform to all applicable statutory requirements. Any applicable requirement of any applicable statute that has been omitted from this Bond shall be deemed to be included herein as if set forth at length. If any provision of this Bond conflicts with any applicable statute, then the provision of said statute shall govern and the remainder of this Bond that is not in conflict therewith shall continue in full force and effect.

11. The term "Bid" as used herein includes a Bid, offer, or proposal as applicable.

RESIDENT/NONRESIDENT BIDDER STATUS/CONSTRUCTION CONTRACTOR'S LICENSING AND PUBLIC WORKS BOND FORM

DURHAM WRRF PHASE 6B DIGESTER
PROJECT NO. 7203

Oregon law (ORS 279A.120) requires Owner, in determining the lowest responsible bidder, to add a percent increase on the bid of a nonresident bidder equal to the percent, if any, of the preference given to bidders in the state in which that bidder resides. Consequently, each bidder must indicate whether it is a resident or nonresident bidder. A resident bidder is a bidder who has paid unemployment taxes or income taxes in Oregon during the 12 calendar months immediately preceding submission of this bid, and has a business address in Oregon, and has stated in its bid whether the bidder is a "resident bidder." A "nonresident bidder" is a bidder who is not a resident bidder.

The bidder whose signature appears on the Bid Forms states that it is: (check one)

1. A resident bidder _____

2. A nonresident bidder _____

Indicate state in which bidder resides: _____

CONSTRUCTION CONTRACTOR'S LICENSING

Oregon law requires all contractors to be licensed with the Oregon Construction Contractors Board in order to submit a Bid to do work and to do work as a contractor. The bidder whose signature appears on the Bid Forms states it is licensed with the Oregon Construction Contractors Board.

Indicate Bidder's Construction Contractors Board License No. _____.

PUBLIC WORKS BOND INFORMATION

Name of Bidder's Public Works Bonding Company: _____

Address of Bidder's Public Works Bonding Company _____

_____

Agent Name/Phone: _____

Bidder's Public Works Bond Number: _____

If exempt under ORS 279C.836(7), check the box: ☐

FIRST-TIER SUBCONTRACTOR DISCLOSURE FORM

FOR

DURHAM WRRF PHASE 6B DIGESTER
PROJECT NO. 7203

Bid Closing: _____

Disclosure Submittal Deadline: 4:00:00 p.m. on _____

This form must be submitted at the location specified in the Advertisement for Bids on the advertised bid closing date and within two working hours after the advertised bid closing time.

List below the names of each subcontractor that will be furnishing labor or furnishing labor and materials and that is required to be disclosed, the category of work that the subcontractor will be performing and the dollar value of the subcontract. Enter 'NONE' if there are no subcontractors that need to be disclosed (ATTACH ADDITIONAL SHEETS IF NEEDED).

Subcontractor Name	**Dollar Value**	**Category of Work**

Failure to submit this form by the disclosure deadline will result in a nonresponsive bid. A nonresponsive bid will not be considered for award.

Form Submitted by (Bidder Name): _____

Contact Name: _____ Phone No.: _____

END OF BID FORMS

PART 2

CONTRACTING REQUIREMENTS

SECTION 00500
AGREEMENT

THIS AGREEMENT is dated as of the _____ day of _____, 20___ by (the "Effective Date") and between Clean Water Services (Owner) and _____ (Contractor).

Owner and Contractor, in consideration of the mutual covenants hereinafter set forth, agree as follows:

ARTICLE 1. WORK.

1.1 Contractor shall complete the Work as specified or indicated in Owner's Contract Documents entitled Durham WRRF Phase 6B Digester Project No. 7203. The Work is generally described as follows:

Furnish all labor, materials, and equipment necessary to:

a. Construct and commission a new 1.3-million gallon, cast-in-place concrete, anaerobic digester with a vertical mixer mixing system (new digester).

b. Install and commission new digester support systems including, but not limited to, a new spiral heat exchanger, hot water pump and piping, digester sludge recirculation pump and piping, grinder, and associated control valves. Install and commission new redundant digester sludge recirculation pumps for the existing Digester Complex 2 (DC2) digesters 1 and 2.

c. Construct digester gas system improvements including, but not limited to, new digester pressure relief and vacuum valves, foam separator, moisture separator, gas flow meter, isolation valves and piping associated with the new digester.

d. Construct a new access bridge from the DC2 control building to the new digester.

e. Modify the existing DC2 digesters, including, but not limited to, adding fall protection tie off anchors at roof access hatches, access modifications to the digester overflow box, replacement of existing overflow isolation slide gates with new knife gates, and installation of new digester gas isolation valves.

f. Construct improvements to the Digester Complex 1 (DC1) flare including, but not limited to, a new modulating waste gas burner (WGB) bypass valve, new regulator, new WGB electronic controller, new spark generator and panel, a new uninterruptible power supply, and new exposed and buried digester gas piping.

g. Install and commission new actuated valves for the digester feed to DC1 and DC2 in the basement of the Solids Building.

h. Install and commission a new Fats, Oils, and Grease (FOG) feed train to the new digester including a progressive cavity feed pump, flow meter, control valve, and piping from the Brown Grease Receiving Facility.

i. Install and commission two new high-efficiency, condensing natural gas boilers, boiler loop pumps, associated hot water system piping, and valve modifications.

j. Remove and replace the primary and secondary hot water system pumps, including associated hot water piping system modifications.

k. Install and commission a new hot water recirculation pump for the FOG offloading screen non-potable water hot water system.

l. Demolish the existing DC 2 electrical room air handling unit and condenser. Install and commission a new air handling unit and condenser and upsize the supply and return ductwork.

m. Site improvements including, but not limited to, a new decant facility, site lighting, drainage improvements, irrigation sleeves, topsoil and compost, asphalt roadways and curb and gutter improvements.

n. New motor control center, electrical panelboards, transformers, instrumentation, and associated conduits and conductors.

o. Upgrades to the existing electrical, instrumentation and Supervisory Control and Data Acquisition systems necessary (equipment replacement or improvements) to support the modifications.

p. Furnish and install related equipment, temporary items and systems, and other appurtenances necessary to complete the Work and to provide a complete and functional system in accordance with the Contract Documents.

ARTICLE 2. ENGINEER.

2.1 The Project has been designed by Jacobs Engineering Group Inc. (Engineer), who is to act as Owner's representative, assume duties and responsibilities, and has the rights and authority assigned to Engineer in the Contract Documents.

ARTICLE 3. CONTRACT TIMES.

3.1 Time of the Essence: Time limits for Milestones, if any, Substantial Completion, and completion and readiness for final payment as stated in the Contract Documents are of the essence of the Contract.

3.2 Days to Achieve Substantial Completion and Final Completion:

3.2.1 Contractor shall achieve Substantial Completion of the Work within the number of days indicated below from the date when the Contract Times commence to run as provided in Paragraph 4.01 of the General Conditions, and completed and ready for final payment in accordance with Paragraph 15.06 of the General

Conditions within the number of days indicated below after the date when the Contract Times commence to run.

Substantial Completion	784 calendar days
Final Completion	836 calendar days

3.3 Dates for Substantial Completion of Milestones:

3.3.1 The Work necessary to achieve the Milestone(s), as identified in Section 01140, Work Restrictions shall be substantially completed by the date identified below from the date when the Contract Times commence to run as provided in Paragraph 4.01 of the General Conditions.

Milestone 1 – New digester ready for functional testing with sludge. November 15, 2027

ARTICLE 4. LIQUIDATED DAMAGES.

4.1 Owner and Contractor recognize that time is of the essence of this Agreement and that Owner will suffer financial loss if the Work is not completed within the time(s) specified in Article 3 herein, plus any extensions thereof allowed in accordance with Article 11 of the General Conditions. The parties also recognize the delays, expense, and difficulties involved in determining in a legal or other dispute resolution proceeding the actual loss suffered by Owner if the Work is not completed on time. Accordingly, instead of requiring any such proof, Owner and Contractor agree that as liquidated damages for delay (but not as a penalty) Contractor shall pay Owner the following amounts for each day that expires after the time specified in Article 3 herein:

Contract Time	Liquidated Damages per Day
1) Substantial Completion	$3,200
2) Final Completion	$2,500

4.2 In addition, Contractor shall pay damages of impacts to other contractors/suppliers affected by Contractor delays.

4.3 Owner shall recover liquidated damages by deducting the amount owed by Change Order or from the final payment or any retainage held by Owner, or if such amounts are insufficient, Contractor shall pay Owner. Owner will assess liquidated damage amounts cumulatively for failure to meet each Milestone, Substantial Completion or Final Completion of the Work date in Article 3 herein as applicable.

ARTICLE 5. CONTRACT PRICE.

5.1 Owner shall pay Contractor for completion of the Work in accordance with the Contract Documents in current funds the amount(s) set forth in the conformed Bid Forms, which are included as an attachment to this Agreement. The Contract Price is as follows:

5.1.1 A Contract Price of **$**_____ for lump sum work, together with

5.1.2 The amount earned, as determined by actual quantities of work performed and paid for at the unit prices set forth in the Bid Forms, subject to additions and deductions, as provided for in the Contract Documents.

ARTICLE 6. PAYMENT PROCEDURES.

6.1 Contractor shall submit Applications for Payment in accordance with Article 15 of the General Conditions. Applications for Payment will be processed by Engineer as provided in the General Conditions.

6.2 Progress Payments and Retainage: Prior to Final Completion, Owner will retain from progress payments and any incentive payment, five percent of the value of the work completed unless Owner approves a surety bond per Article 6.4. Contractor may elect to have Owner retain the monies in one of the forms specified in Article 6.3 or Article 6.4 by completing a Selection of Retainage Option Form. Amounts retained and interest earned will be included in the final payment made according to Paragraph 15.01.C.6 of the General Conditions, unless otherwise specified in the Contract. Owner will make progress payments on account of the Contract Price on the basis of Contractor's Application for Payment on the date of each month as established in the preconstruction conference during performance of the Work as provided herein. All such payments will be measured by the Schedule of Values established as provided in Paragraph 2.05 of the General Conditions (and in the case of Unit Price Work based on the number of units completed) or, in the event there is no Schedule of Values, as provided in the General Conditions.

6.3 In lieu of retainage, Contractor may elect on the Selection of Retainage Option Form to have accumulated funds deposited by Owner, as provided in ORS 279C.560, in an interest-bearing account. Interest on such an account would accrue to Contractor. Costs incurred by Owner as a result of this option will be deducted from Contractor's final payment.

6.4 In lieu of retainage Contractor, with the approval of Owner, may elect on the Selection of Retainage Option Form to deposit a surety bond for all or any portion of the retainage in a form acceptable to Owner. Such bond and any proceeds therefrom shall be made subject to all claims and liens as provided for in ORS 279C.550 to 279C.620. Costs incurred by Owner as a result of this option will be deducted from Contractor's final payment.

6.5 Upon Substantial Completion, Owner will pay an amount sufficient to increase total payments to Contractor to 100 percent of the Work completed, less retainage and such amounts as Engineer will determine in accordance with Paragraph 15.01.C.6 of the General Conditions and less 100 percent of Engineer's estimate of the value of Work to be completed or corrected as shown on the tentative list of items to be completed or corrected attached to the certificate of Substantial Completion.

6.6 Final Payment:

6.6.1 Upon Final Completion and acceptance of the Work in accordance with Paragraph 15.06 of the General Conditions, Owner will pay the remainder of the Contract Price as recommended by Engineer as provided in Paragraph 15.06.

ARTICLE 7. INTEREST

7.1 Monies not paid when due as provided in Article 15 of the General Conditions shall bear interest at the rate as provided for in ORS 279C.570.

7.2 Interest on retainage withheld by Owner, if any, will be paid in accordance with Article 6.2.

ARTICLE 8. PREVAILING WAGE RATES/BOLI FEE/PUBLIC WORKS BOND REQUIRED.

8.1 The Project is a public works project. Contractor agrees that the provisions required by ORS 279C.830 pertaining to Contractor's payment of prevailing wage rates shall be included as part of this Agreement. Contractor must pay workers in each trade or occupation that Contractor or its Subcontractors or other person who is a party to the Contract uses in performing all or part of the Contract not less than the specific minimum hourly rate of wages in accordance with ORS 279C.838 and 279C.840 and shall require its Subcontractors to pay at such rates. The applicable Oregon prevailing wage rates for such workers are incorporated by reference in Section 00810, Oregon Prevailing Wage Rates. Contractors shall include in every subcontract a provision requiring subcontractors to pay their workers at such rates.

8.2 Owner will be responsible for paying the fee required by ORS 279C.825 to the Commissioner of the Bureau of Labor and Industries.

8.3 Before starting any Work on the Project, Contractor and every Subcontractor performing Work on the Project must have a public works bond filed with the Construction Contractors Board, unless exempt under ORS 279C.836(4), (7), (8), or (9). Contractor must require in every subcontract that the Subcontractor have a public works bond filed with the Construction Contractors Board before starting Work on the Project unless exempt under ORS 279C.836(4), (7), (8), or (9).

ARTICLE 9. CONTRACTOR'S REPRESENTATIONS

9.1 In order to induce Owner to enter into this Agreement, Contractor makes the following representations:

9.1.1 Contractor has examined and carefully studied the Contract Documents and any other related data identified in the Bidding Documents**.**

9.1.2 Contractor has visited the Site and become familiar with and is satisfied as to the general, local, and Site conditions that may affect cost, progress, and performance of the Work.

9.1.3 Contractor is familiar with and is satisfied as to all federal, state, and local Laws and Regulations that may affect cost, progress, and performance of the Work.

9.1.4 Contractor has carefully studied: (1) reports of explorations and tests of subsurface conditions at or contiguous to the Site and drawings of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities) if any, which have been identified in Paragraph 5.03 of the Supplementary Conditions as containing reliable "Technical Data", and (2) reports and drawings of Hazardous Environmental Conditions, if any, at the Site which have been identified in Paragraph 5.06 of the Supplementary Conditions as containing reliable "Technical Data."

9.1.5 Contractor has considered the information known to Contractor; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Contract Documents; and Site-related reports and drawings identified in the Contract Documents, with respect to the effect of such information, observations, and documents on 1) the cost, progress, and performance of the Work; 2) the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, including any specific means, methods, techniques, sequences, and procedures of construction expressly required by the Contract Documents; and 3) Contractor's safety precautions and programs.

9.1.6 Based on the information and observations referred to above, Contractor does not consider that any further examinations, investigations, explorations, tests, studies, or data are necessary for the performance of the Work at the Contract Price, within the Contract Times, and in accordance with the other terms and conditions of the Contract Documents.

9.1.7 Contractor is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Contract Documents.

9.1.8 Contractor has given Engineer written notice of conflicts, errors, ambiguities, or discrepancies that Contractor has discovered in the Contract Documents, and the written resolution thereof by Engineer is acceptable to Contractor.

9.1.9 The Contract Documents are generally sufficient to indicate and convey understanding of terms and conditions for performance and furnishing of the Work.

ARTICLE 10. CONTRACT DOCUMENTS.

10.1 The Contract Documents which comprise the entire Agreement between Owner and Contractor concerning Work are:

10.1.1 This Agreement.

10.1.2 Conformed Bid Forms.

10.1.3 Executed Performance and Payment Bonds.

10.1.4 Contract Specifications: Divisions 00 and 01 (Except Section 00030, Advertisement to Bid, and Section 00100, Instructions to Bidders); Divisions 02 through 17.

10.1.5 Contract Drawings.

10.1.6 General Conditions.

10.1.7 Supplementary Conditions.

10.1.8 Specifications as listed in the table of contents of the Project Manual.

10.1.9 Drawings consisting of 172 sheets with each sheet bearing the following general title: “Durham WRRF Phase 6B Digester, Project No. 7203”.

10.1.10 Standard Details consisting of 162 pages with each detail bearing the following general title: “Durham WRRF Phase 6B Digester”.

10.1.11 Addenda numbers ___ to ___, inclusive.

10.1.12 Selection of Retainage Option Form if applicable.

10.1.13 Permits from outside agencies.

10.2 There are no Contract Documents other than those listed in this Article.

10.3 The Contract Documents may only be amended, modified, or supplemented as provided in Article 11 of the General Conditions.

ARTICLE 11. ASSIGNMENT.

11.1 Owner and Contractor each binds itself, its partners, successors, assigns and legal representatives to the other party hereto, its partners, successors, assigns and legal representatives in respect to all covenants, agreements and obligations contained in the Contract Documents.

11.2 No assignment by a party hereto of any rights under or interests in the Contract Documents will be binding on another party hereto without the written consent of the party sought to be bound; and specifically but without limitation, monies that may become due and monies that are due may not be assigned without such consent (except to the extent that the effect of this restriction may be limited by law), and unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility under the Contract Documents.

ARTICLE 12. PAYROLL AND CERTIFIED STATEMENT FILING AND ADDITIONAL RETAINAGE.

12.1 Contractor or Contractor's surety, and every subcontractor or subcontractor's surety, shall file with Owner written payroll and certified statements (Certified Payrolls) that accurately and completely contain the payroll records for each week during which the

Contractor or subcontractor employs a worker on a public works project. The Certified Payrolls shall contain the information required and conform to the requirements set forth in ORS 279C.845 and Oregon Administrative Rule 839-025-0010. Contractor shall file the Certified Payrolls with Owner once a month by the fifth business day of the following month. Once construction starts Contractor shall file a Certified Payroll with Owner containing the notation "No Work" each week that Contractor does not work on the Project.

12.2 Owner shall retain 25 percent of any amount earned by Contractor, in addition to other retainage, on the Work until Contractor has filed with Owner the required Certified Payrolls. Owner shall pay Contractor the amount retained under this Section within 14 days after the Contractor files the required Certified Payrolls required by this Article regardless of whether a subcontractor has failed to file Certified Payrolls. Owner is not required to verify the truth of the contents of the Certified Payrolls filed by Contractor.

12.3 Contractor shall retain 25 percent of any amount earned by a first-tier subcontractor on the Work until the subcontractor has filed with Owner the required Certified Payrolls. Contractor shall verify that the first-tier subcontractor has filed the Certified Payrolls before the Contractor may pay the subcontractor any amount retained under this Article. Contractor shall pay the first-tier subcontractor the amount retained under this Article within 14 days after the subcontractor files the Certified Payrolls required by this Article. Neither Owner nor Contractor is required to verify the truth of the contents of the Certified Payrolls filed by the first-tier subcontractor.

ARTICLE 13. MISCELLANEOUS

13.1 Terms used in this Agreement will have the meanings stated in the General Conditions and the Supplementary Conditions.

13.2 Severability: Any provision or part of the Contract Documents held to be void or unenforceable under any Law or Regulation shall be deemed stricken, and remaining provisions shall continue to be valid and binding upon Owner and Contractor, who agree the Contract Documents shall be reformed to replace such stricken provision or part thereof with a valid and enforceable provision that comes as close as possible to expressing the intention of the stricken provision.

13.3 Interpretation of Contract: The Contract Documents shall not be construed for or against any party by reason of the authorship or alleged authorship of any provision. The paragraph headings contained in the Contract Documents are for ease of reference only and shall not be used in construing or interpreting the Contract Documents.

13.4 This Agreement, and any Change Orders may be executed in several counterparts, each of which will be an original, all of which will constitute one and the same instrument. An electronic signature will be considered an original. The individuals signing this Agreement, and any future Change Orders or amendments certify that they are authorized to execute this Agreement and any future Change Order or amendments on behalf of Contractor and Owner, respectively.

IN WITNESS WHEREOF, Owner and Contractor have caused this Agreement to be executed the day and year first above written.

OWNER

CLEAN WATER SERVICES

By _____
Chief Executive Officer or Designee

APPROVED AS TO FORM

_____
Clean Water Services Counsel

CONTRACTOR

_____

By _____

Title _____

AGREEMENT CERTIFICATE

(if Corporation)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Board of Directors of_____

_____,

a corporation existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____(signer name), as President of the Corporation, be and is hereby authorized to execute the Agreement for the Durham WRRF Phase 6B Digester Project No. 7203 by and between this Corporation and Clean Water Services and that their execution thereof, attested by the Secretary of the Corporation, shall be the official act and deed of this Corporation."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____, day of _____, 20___.

By: _____
President

Attested:

By:_____
Secretary

Print Name: _____

AGREEMENT CERTIFICATE
(if Limited Liability Company)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Members or Managers of

_____,
(Insert Limited Liability Company Name Here)

a limited liability company existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____ (signer name), as the _____ _____ (signer title) of the limited liability company, be and is hereby authorized to execute the Agreement for the Durham WRRF Phase 6B Digester Project No. 7203 by and between this limited liability company and Clean Water Services and that their execution thereof, attested by the _____ (attester title) shall be the official act and deed of this limited liability company."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____, day of _____, 20___.

By: _____

Title: _____

Attested:

By: _____

Name/Title: _____

AGREEMENT CERTIFICATE
(if Partnership)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Partners of_____

_____,

a partnership existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____(signer name), as Partner of the Partnership, be and is hereby authorized to execute the Agreement for Durham WRRF Phase 6B Digester Project No. 7203 by and between this Partnership and Clean Water Services and that their execution thereof, attested by the _____ _____(attester title)shall be the official act and deed of this Partnership."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____, day of _____, 20___.

By:_____
Partner

Attested:

By: _____

Name/Title: _____

AGREEMENT CERTIFICATE
(if Joint Venture)

STATE OF _____)
) ss:
COUNTY OF _____)

I HEREBY CERTIFY that a meeting of the Principals of_____

_____

_____,

a joint venture existing under the laws of the State of _____, was held on _____, 20___, and the following resolution was duly passed and adopted:

"RESOLVED, that _____(signer name), as Managing Partner of the Joint Venture, be and is hereby authorized to execute the Agreement for the Durham WRRF Phase 6B Digester Project No. 7203 by and between this Joint Venture and Clean Water Services and that their execution thereof, attested by the _____(attester title) shall be the official act and deed of this Joint Venture."

I further certify that the resolution is now in full force and effect.

IN WITNESS WHEREOF, I have hereunto set my hand this _____, day of _____, 20___.

By:_____
Managing Partner

Attested:

By: _____

Name/Title: _____

SELECTION OF RETAINAGE OPTION FORM

(ORS 279C.560)

_____(insert name of Contractor) (Contractor) either intends to enter or has entered into a contract with Clean Water Services (Owner) for the Durham WRRF Phase 6B Digester, Project No. 7203 (Project). If Owner decides to withhold retainage, it will be in the amount of five percent of the contract price of the work completed and will be held by Owner for up to 30 days after the Project has been accepted by Owner in writing. Oregon law allows specific alternatives for the holding and accounting of this retainage at the option of the Contractor. **FAILURE TO EXECUTE AND SUBMIT THIS FORM WITHIN 15 DAYS OF OWNER'S REQUEST WILL RESULT IN AUTOMATIC SELECTION OF THE FIRST OPTION**. **IF NO OPTION IS SELECTED, OWNER WILL WITHHOLD RETAINAGE BUT WILL NOT PAY INTEREST ON THE RETAINAGE.**

Contractor elects the following option to provide retainage for the Project. (**Check one only.**)

_____ 1. **Any Contract Price** – **Cash Retainage**. When Contractor has not elected either option 2 or 3 below within the 15-day period, District will hold all retained moneys in a District fund or account and interest is not required to accrue on the retained moneys.

_____ 2. **Any Contract Price – Contractor Provided Account.** If selected, Contractor will set up an interest-bearing account in a commercial bank or trust company in Oregon _____(name of lending institution) in the name of Owner. Owner will place the five percent retainage withheld from each progress payment, into the interest-earning account. Funds in the account will be under Owner's control and will be released to Contractor within 30 days of final acceptance of the Project. Interest on the account will accrue to Contractor. Contractor will provide a bank letter that includes ACH instructions.

Bank Contact_____

Contact telephone number_____

_____ 3. **Any Contract Price – Contractor-Provided Retainage Bond.** If selected and before the first progress payment is made where retainage will be withheld, Contractor will deposit acceptable bonds or securities, equal to at least five percent of the remaining contract amount, with Owner or with a bank or trust company authorized to transact business in Oregon and not a surety obligation of an individual. The bank or trust company will provide a safekeeping receipt to Owner. **The securities must cover <u>all</u> of the retainage.**

A. Acceptable bonds and securities to be held in lieu of retainage:

1. Bills, certificates, notes, bonds, or other obligations of the United States, its agencies, or its wholly-owned corporations.

2. Indebtedness of the Federal National Mortgage Association.
3. Surety Bond must substantially be in the form in ORS 701.435 and acceptable to Owner.

B. Complete only if Option 3 is selected:

The Contractor will deposit _____
_____
_____
(description of bonds or securities) in the amount of $ _____
_____with
_____ (depository name and address) on _____(date) and instruct the named depository to provide Owner with a safekeeping receipt and to hold the bonds or securities until authorized by Owner to release them.

CONTRACTOR NAME

_____	_____
Company Name	Federal Tax I.D. Number
_____	_____
By (Signature)	By (Please print)
_____	_____
Title	Date

END OF SECTION

SECTION 00610
PERFORMANCE BOND

DURHAM WRRF PHASE 6B DIGESTER
PROJECT NO. 7203

Any singular reference to Contractor, Surety, Owner, or other party shall be considered plural where applicable.

CONTRACTOR
(Name and Address):

SURETY
(Name and Address of Principal Place of Business):

OWNER (Name and Address): Clean Water Services, 2550 SW Hillsboro Hwy., Hillsboro, Oregon, 97123

CONTRACT
Date:
Amount:
Description (Name and Location): Durham WRRF Phase 6B Digester Project No. 7203
Durham Water Resource Recovery Facility, 16580 SW 85th Avenue, Tigard, Oregon 97224

BOND
Bond Number:
Date (Not earlier than Contract Date):
Amount:
Modifications to this Bond Form:

Surety and Contractor, intending to be legally bound hereby, subject to the terms of this Performance Bond, do each cause this Performance Bond to be duly executed on its behalf by its authorized officer, agent, or representative.

CONTRACTOR AS PRINCIPAL

Company: _____
(Seal)

By: _____
Signature

_____
Name

_____
Title

SURETY

Surety: _____
(Seal)

By: _____
Signature

_____
Title (Attach Power of Attorney)

Approved as to Form

_____
Owner's Counsel

Attest: _____
Signature

_____
Title

1. Contractor and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors, and assigns to Owner for the performance of the Contract, which is incorporated herein by reference.

2. If Contractor performs the Contract, Surety and Contractor have no obligation under this Bond, except to participate in conferences as provided in Paragraph 3.1.

3. If there is no Owner Default, Surety's obligation under this Bond shall arise after:

3.1. Owner has notified Contractor and Surety, at the addresses described in Paragraph 10 below, that Owner is considering declaring a Contractor Default and has requested and attempted to arrange a conference with Contractor and Surety to be held not later than 15 days after receipt of such notice to discuss methods of performing the Contract. If Owner, Contractor and Surety agree, Contractor shall be allowed a reasonable time to perform the Contract, but such an agreement shall not waive Owner's right, if any, subsequently to declare a Contractor Default; and

3.2. Owner has declared a Contractor Default and formally terminated Contractor's right to complete the Contract. Such Contractor Default shall not be declared earlier than 20 days after Contractor and Surety have received notice as provided in Paragraph 3.1; and

3.3. Owner has agreed to pay the Balance of the Contract Price to:

1. Surety in accordance with the terms of the Contract;

2. Another contractor selected pursuant to Paragraph 4.3 to perform the Contract.

4. When Owner has satisfied the conditions of Paragraph 3, Surety shall promptly and at Surety's expense take one of the following actions:

4.1. Arrange for Contractor, with consent of Owner, to perform and complete the Contract; or

4.2. Undertake to perform and complete the Contract itself, through its agents or through independent contractors; or

4.3. Obtain bids or negotiated proposals from qualified contractors acceptable to Owner for a contract for performance and completion of the Contract, arrange for a contract to be prepared for execution by Owner and Contractor selected with Owner's concurrence, to be secured with performance and payment bonds executed by a qualified surety equivalent to the bonds issued on the Contract, and pay to Owner the amount of damages as described in Paragraph 6 in excess of the Balance of the Contract Price incurred by Owner resulting from Contractor Default; or

4.4. Waive its right to perform and complete, arrange for completion, or obtain a new contractor and with reasonable promptness under the circumstances:

1. After investigation, determine the amount for which it may be liable to Owner and, as soon as practicable after the amount is determined, tender payment therefor to Owner; or

2. Deny liability in whole or in part and notify Owner citing reasons therefor.

5. If Surety does not proceed as provided in Paragraph 4 with reasonable promptness, Surety shall be deemed to be in default on this Bond 15 days after receipt of an additional written notice from Owner to Surety demanding that Surety perform its obligations under this Bond, and Owner shall be entitled to enforce any remedy available to Owner. If Surety proceeds as provided in Paragraph 4.4, and Owner refuses the payment tendered or Surety has denied liability, in whole or in part, without further notice Owner shall be entitled to enforce any remedy available to Owner.

6. After Owner has terminated Contractor's right to complete the Contract, and if Surety elects to act under Paragraph 4.1, 4.2, or 4.3 above, then the responsibilities of Owner to Surety shall not be greater than those of Owner under the Contract. To a limit of the amount of this Bond, but subject to commitment by Owner of the Balance of the Contract Price to mitigation of costs and damages on the Contract, Surety is obligated without duplication for:

6.1. The responsibilities of Contractor for correction of defective Work and completion of the Contract;

6.2. Additional legal, design professional, and delay costs resulting from Contractor's Default, and resulting from the actions or failure to act of Surety under Paragraph 4; and

6.3. Liquidated damages, or if no liquidated damages are specified in the Contract, actual damages caused by delayed performance or non-performance of Contractor.

6.4. Any other damages that Contractor is responsible for under the Contract and under law.

7. No right of action shall accrue on this Bond to any person or entity other than Owner or its heirs, executors, administrators, or successors.

8. Surety hereby waives notice of any change, including changes of time, to Contract or to related subcontracts, purchase orders, and other obligations.

9. In the event arbitration, litigation or any other proceeding is brought upon this bond by Owner and judgment or award is entered in Owner's favor, Surety shall pay all of Owner's costs incurred in such arbitration, litigation or other proceeding, including any attorney and expert witness fees. In the event there is an arbitration clause in the Contract, Surety agrees to participate in and to be bound by any such arbitration to the same extent Contractor is bound.

10. Notice to Surety, Owner, or Contractor shall be mailed or delivered to the address shown on the signature page.

11. When this Bond has been furnished to comply with a statutory requirement in the location where the Contract was to be performed, any provision in this Bond conflicting with said statutory requirement shall be deemed deleted herefrom and provisions conforming to such statutory requirement shall be deemed incorporated herein. The intent is that this Bond shall be construed as a statutory bond and not as a common law bond.

12. Definitions.

12.1. Balance of the Contract Price: The total amount payable by Owner to Contractor under the Contract after all proper adjustments have been made, including allowance to Contractor of any amounts received or to be received by Owner in settlement of insurance or other Claims for damages to which Contractor is entitled, reduced by all valid and proper payments made to or on behalf of Contractor under the Contract.

12.2. Contract: The agreement between Owner and Contractor identified on the signature page, including all Contract Documents and changes thereto.

12.3. Contractor Default: Failure of Contractor, which has neither been remedied nor waived, to perform or otherwise to comply with the terms of the Contract.

12.4. Owner Default: A material failure of Owner, which has neither been remedied nor waived, to pay Contractor undisputed amounts as required by the Contract or to perform and complete or comply with the other material terms thereof.

FOR INFORMATION ONLY – Name, Address and Telephone Surety Agency or Broker Owner's Representative (engineer or other party)

END OF SECTION

SECTION 00630
PAYMENT BOND

DURHAM WRRF PHASE 6B DIGESTER
PROJECT NO. 7203

Any singular reference to Contractor, Surety, Owner, or other party shall be considered plural where applicable.

CONTRACTOR
(Name and Address):

SURETY
(Name and Address of Principal Place of Business):

OWNER (Name and Address): Clean Water Services, 2550 SW Hillsboro Hwy., Hillsboro, Oregon, 97123

CONTRACT

Date:
Amount:
Description (Name and Location): Durham WRRF Phase 6B Digester Project No. 7203
Durham Water Resource Recovery Facility, 16580 SW 85th Avenue, Tigard, Oregon 97224

BOND

Bond Number:
Date (Not earlier than Contract Date):
Amount:
Modifications to this Bond Form:

Surety and Contractor, intending to be legally bound hereby, subject to the terms of this Payment Bond, do each cause this Payment Bond to be duly executed on its behalf by its authorized officer, agent, or representative.

CONTRACTOR AS PRINCIPAL

Company: _____
(Seal)

By: _____
Signature

_____
Name

_____
Title

SURETY

Surety: _____
(Seal)

By: _____
Signature

_____
Title (Attach Power of Attorney)

Approved as to Form

_____
Owner's Counsel

Attest: _____
Signature

_____
Title

1. Contractor and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors, and assigns to Owner to pay for labor, materials, and equipment furnished by Claimants for use in the performance of the Contract, which is incorporated herein by reference.

2. With respect to Owner, this obligation shall be null and void if Contractor:

2.1. Promptly makes payment, directly or indirectly, for all sums due Claimants, and

2.2. Defends, indemnifies, and holds harmless Owner from all claims, demands, liens, or suits alleging non-payment by Contractor by any person or entity who furnished labor, materials, or equipment for use in the performance of the Contract, provided Owner has promptly notified Contractor and Surety (at the addresses described in Paragraph 12) of any claims, demands, liens, or suits and tendered defense of such claims, demands, liens, or suits to Contractor and Surety, and provided there is no Owner Default.

3. With respect to Claimants, this obligation shall be null and void if Contractor promptly makes payment, directly or indirectly, for all sums due.

4. Surety shall have no obligation to Claimants under this Bond until:

4.1. Claimants who are employed by or have a direct contract with Contractor have given notice to Surety (at the addresses described in Paragraph 12) and sent a copy, or notice thereof, to Owner, stating that a claim is being made under this Bond and, with substantial accuracy, the amount of the claim.

4.2. Claimants who do not have a direct contract with Contractor:

1. Have furnished written notice to Contractor and sent a copy, or notice thereof, to Owner, within 90 days after having last performed labor or last furnished materials or equipment included in the claim stating, with substantial accuracy, the amount of the claim and the name of the party to whom the materials or equipment were furnished or supplied, or for whom the labor was done or performed; and

2. Have either received a rejection in whole or in part from Contractor, or not received within 30 days of furnishing the above notice any communication from Contractor by which Contractor had indicated the claim will be paid directly or indirectly; and

3. Not having been paid within the above 30 days, have sent a written notice to Surety and sent a copy, or notice thereof, to Owner, stating that a claim is being made under this Bond and enclosing a copy of the previous written notice furnished to Contractor.

5. If a notice by a Claimant required by Paragraph 4 is provided by Owner to Contractor or to Surety, that is sufficient compliance.

6. Reserved.

7. Surety's total obligation shall not exceed the amount of this Bond, and the amount of this Bond shall be credited for any payments made in good faith by Surety.

8. Reserved.

9. Owner shall not be liable for payment of any costs or expenses of any Claimant under this Bond, and shall have under this Bond no obligations to make payments to, give notices on behalf of, or otherwise have obligations to Claimants under this Bond.

10. Surety hereby waives notice of any change, including changes of time, to the Contract or to related Subcontracts, purchase orders and other obligations.

11. No suit or action shall be commenced by a Claimant under this Bond other than in a court of competent jurisdiction in the location in which the Work or part of the Work is located or after the expiration of one year from the date (1) on which the Claimant gave the notice required by Paragraph 4.1 or Paragraph 4.2.3, or (2) on which the last labor or service was performed by anyone or the last materials or equipment were furnished by anyone under the Construction Contract, whichever of (1) or (2) first occurs. If the provisions of this paragraph are void or prohibited by law, the minimum period of limitation available to sureties as a defense in the jurisdiction of the suit shall be applicable.

12. Notice to Surety, Owner, or Contractor shall be mailed or delivered to the addresses shown on the signature page. Actual receipt of notice by Surety, Owner, or Contractor, however accomplished, shall

be sufficient compliance as of the date received at the address shown on the signature page.

13. When this Bond has been furnished to comply with a statutory requirement in the location where the Contract was to be performed, any provision in this Bond conflicting with said statutory requirement shall be deemed deleted herefrom and provisions conforming to such statutory requirement shall be deemed incorporated herein. The intent is that this Bond shall be construed as a statutory Bond and not as a common law bond.

14. Upon request of any person or entity appearing to be a potential beneficiary of this Bond, Contractor shall promptly furnish a copy of this Bond or shall permit a copy to be made.

15. Definitions:

15.1. Claimant: An individual or entity having a direct contract with Contractor, or with a first-tier subcontractor of Contractor, to furnish labor, materials, or equipment for use in the performance of the Contract. The intent of this Bond shall be to include without limitation in the terms "labor, materials or equipment" that part of water, gas, power, light, heat, oil, gasoline, telephone service, or rental equipment used in the Contract, architectural and engineering services required for performance of the Work of Contractor and Contractor's Subcontractors, and all other items for which a mechanic's lien may be asserted in the jurisdiction where the labor, materials, or equipment were furnished.

15.2. Contract: The agreement between Owner and Contractor identified on the signature page, including all Contract Documents and changes thereto.

15.3. Owner Default: A material failure of Owner, which has neither been remedied nor waived, to pay Contractor undisputed amounts as required by the Contract or to perform and complete or comply with the material other terms thereof.

FOR INFORMATION ONLY – Name, Address and Telephone Surety Agency or Broker: Owner's Representative (engineer or other party):

END OF SECTION

STANDARD GENERAL CONDITIONS OF THE CONSTRUCTION CONTRACT

Prepared by

Issued and Published Jointly by

These General Conditions have been prepared for use with the Agreement Between Owner and Contractor for Construction Contract (EJCDC® C-520, Stipulated Sum, or C-525, Cost-Plus, 2013 Editions). Their provisions are interrelated and a change in one may necessitate a change in the other.

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ARTICLE 1 – DEFINITIONS AND TERMINOLOGY

1.01 *Defined Terms*

A. Wherever used in the Bidding Requirements or Contract Documents, a term printed with initial capital letters, including the term's singular and plural forms, will have the meaning indicated in the definitions below. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*—Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the proposed Contract Documents.

2. *Agreement*—The written instrument, executed by Owner and Contractor, that sets forth the Contract Price and Contract Times, identifies the parties and the Engineer, and designates the specific items that are Contract Documents.

3. *Application for Payment*—The form acceptable to Engineer which is to be used by Contractor during the course of the Work in requesting progress or final payments and which is to be accompanied by such supporting documentation as is required by the Contract Documents.

4. *Bid*—The offer of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

5. *Bidder*—An individual or entity that submits a Bid to Owner.

6. *Bidding Documents*—The Bidding Requirements, the proposed Contract Documents, and all Addenda.

7. *Bidding Requirements*—The advertisement or invitation to bid, Instructions to Bidders, Bid Bond or other Bid security, if any, the Bid Form, and the Bid with any attachments.

8. *Change Order*—A document which is signed by Contractor and Owner and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, or other revision to the Contract, issued on or after the Effective Date of the Contract.

9. *Change Proposal*—A written request by Contractor, duly submitted in compliance with the procedural requirements set forth herein, seeking an adjustment in Contract Price or Contract Times, or both; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; challenging a set-off against payments due; or seeking other relief with respect to the terms of the Contract.

10. *Claim*—(a) A demand or assertion by Owner directly to Contractor, duly submitted in compliance with the procedural requirements set forth herein: seeking an adjustment of Contract Price or Contract Times, or both; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; contesting Engineer's decision regarding a Change Proposal; seeking resolution of a contractual issue that Engineer has declined to address; or seeking other relief with respect to the terms of the Contract; or (b) a demand or assertion by Contractor directly to Owner, duly submitted in compliance with the procedural requirements set forth herein, contesting Engineer's decision regarding a Change Proposal; or seeking resolution of a contractual issue that Engineer has declined to address. A demand for money or services by a third party is not a Claim.

11. *Constituent of Concern*—Asbestos, petroleum, radioactive materials, polychlorinated biphenyls (PCBs), hazardous waste, and any substance, product, waste, or other material of any nature whatsoever that is or becomes listed, regulated, or addressed pursuant to (a) the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. §§9601 et seq. ("CERCLA"); (b) the Hazardous Materials Transportation Act, 49 U.S.C. §§5501 et seq.; (c) the Resource Conservation and Recovery Act, 42 U.S.C. §§6901 et seq. ("RCRA"); (d) the Toxic Substances Control Act, 15 U.S.C.

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§§2601 et seq.; (e) the Clean Water Act, 33 U.S.C. §§1251 et seq.; (f) the Clean Air Act, 42 U.S.C. §§7401 et seq.; or (g) any other federal, state, or local statute, law, rule, regulation, ordinance, resolution, code, order, or decree regulating, relating to, or imposing liability or standards of conduct concerning, any hazardous, toxic, or dangerous waste, substance, or material.

12. *Contract*—The entire and integrated written contract between the Owner and Contractor concerning the Work.

13. *Contract Documents*—Those items so designated in the Agreement, and which together comprise the Contract.

14. *Contract Price*—The money that Owner has agreed to pay Contractor for completion of the Work in accordance with the Contract Documents. .

15. *Contract Times*—The number of days or the dates by which Contractor shall: (a) achieve Milestones, if any; (b) achieve Substantial Completion; and (c) complete the Work.

16. *Contractor*—The individual or entity with which Owner has contracted for performance of the Work.

17. *Cost of the Work*—See Paragraph 13.01 for definition.

18. *Drawings*—The part of the Contract that graphically shows the scope, extent, and character of the Work to be performed by Contractor.

19. *Effective Date of the Contract*—The date, indicated in the Agreement, on which the Contract becomes effective.

20. *Engineer*—The individual or entity named as such in the Agreement.

21. *Field Order*—A written order issued by Engineer which requires minor changes in the Work but does not change the Contract Price or the Contract Times.

22. *Hazardous Environmental Condition*—The presence at the Site of Constituents of Concern in such quantities or circumstances that may present a danger to persons or property exposed thereto. The presence at the Site of materials that are necessary for the execution of the Work, or that are to be incorporated in the Work, and that are controlled and contained pursuant to industry practices, Laws and Regulations, and the requirements of the Contract, does not establish a Hazardous Environmental Condition.

23. *Laws and Regulations; Laws or Regulations*—Any and all applicable laws, statutes, rules, regulations, ordinances, codes, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

24. *Liens*—Charges, security interests, or encumbrances upon Contract-related funds, real property, or personal property.

25. *Milestone*—A principal event in the performance of the Work that the Contract requires Contractor to achieve by an intermediate completion date or by a time prior to Substantial Completion of all the Work.

26. *Notice of Award*—The written notice by Owner to a Bidder of Owner's acceptance of the Bid.

27. *Notice to Proceed*—A written notice by Owner to Contractor fixing the date on which the Contract Times will commence to run and on which Contractor shall start to perform the Work.

28. *Owner*—The individual or entity with which Contractor has contracted regarding the Work, and which has agreed to pay Contractor for the performance of the Work, pursuant to the terms of the Contract.

29. *Progress Schedule*—A schedule, prepared and maintained by Contractor, describing the sequence and duration of the activities comprising the Contractor's plan to accomplish the Work within the Contract Times.

30. *Project*—The total undertaking to be accomplished for Owner by engineers, contractors, and others, including planning, study, design, construction, testing, commissioning, and start-up, and of which the Work to be performed under the Contract Documents is a part.

31. *Project Manual*—The written documents prepared for, or made available for, procuring and constructing

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the Work, including but not limited to the Bidding Documents or other construction procurement documents, geotechnical and existing conditions information, the Agreement, bond forms, General Conditions, Supplementary Conditions, and Specifications. The contents of the Project Manual may be bound in one or more volumes.

32. *Resident Project Representative*—The authorized representative of Engineer assigned to assist Engineer at the Site. As used herein, the term Resident Project Representative or "RPR" includes any assistants or field staff of Resident Project Representative.

33. *Samples*—Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and that establish the standards by which such portion of the Work will be judged.

34. *Schedule of Submittals*—A schedule, prepared and maintained by Contractor, of required submittals and the time requirements for Engineer's review of the submittals and the performance of related construction activities.

35. *Schedule of Values*—A schedule, prepared and maintained by Contractor, allocating portions of the Contract Price to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

36. *Shop Drawings*—All drawings, diagrams, illustrations, schedules, and other data or information that are specifically prepared or assembled by or for Contractor and submitted by Contractor to illustrate some portion of the Work. Shop Drawings, whether approved or not, are not Drawings and are not Contract Documents.

37. *Site*—Lands or areas indicated in the Contract Documents as being furnished by Owner upon which the Work is to be performed, including rights-of-way and easements, and such other lands furnished by Owner which are designated for the use of Contractor.

38. *Specifications*—The part of the Contract that consists of written requirements for materials, equipment, systems, standards, and workmanship as applied to the Work, and certain administrative requirements and procedural matters applicable to the Work.

39. *Subcontractor*—An individual or entity having a direct contract with Contractor or with any other Subcontractor for the performance of a part of the Work.

40. *Substantial Completion*—The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of Engineer, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion thereof.

41. *Successful Bidder*—The Bidder whose Bid the Owner accepts, and to which the Owner makes an award of contract, subject to stated conditions.

42. *Supplementary Conditions*—The part of the Contract that amends or supplements these General Conditions.

43. *Supplier*—A manufacturer, fabricator, supplier, distributor, materialman, or vendor having a direct contract with Contractor or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or a Subcontractor.

44. *Technical Data*—Those items expressly identified as Technical Data in the Supplementary Conditions, with respect to either (a) subsurface conditions at the Site, or physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities) or (b) Hazardous Environmental Conditions at the Site. If no such express identifications of Technical Data have been made with respect to conditions at the Site, then the data contained in boring logs, recorded measurements of subsurface water levels, laboratory test results, and other factual, objective information regarding conditions at the Site that are set forth in any geotechnical or environmental report prepared for the Project and made

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available to Contractor are hereby defined as Technical Data with respect to conditions at the Site under Paragraphs 5.03, 5.04, and 5.06.

45. *Underground Facilities*—All underground pipelines, conduits, ducts, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or attachments, and any encasements containing such facilities, including but not limited to those that convey electricity, gases, steam, liquid petroleum products, telephone or other communications, fiber optic transmissions, cable television, water, wastewater, storm water, other liquids or chemicals, or traffic or other control systems.

46. *Unit Price Work*—Work to be paid for on the basis of unit prices.

47. *Work*—The entire construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction; furnishing, installing, and incorporating all materials and equipment into such construction; and may include related services such as testing, start-up, and commissioning, all as required by the Contract Documents.

48. *Work Change Directive*—A written directive to Contractor issued on or after the Effective Date of the Contract, signed by Owner and recommended by Engineer, ordering an addition, deletion, or revision in the Work.

1.02 *Terminology*

A. The words and terms discussed in the following paragraphs are not defined but, when used in the Bidding Requirements or Contract Documents, have the indicated meaning.

B. Intent of Certain Terms or Adjectives:

1. The Contract Documents include the terms "as allowed," "as approved," "as ordered," "as directed" or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives "reasonable," "suitable," "acceptable," "proper," "satisfactory," or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Work. It is intended that such exercise of professional judgment, action, or determination will be solely to evaluate, in general, the Work for compliance with the information in the Contract Documents and with the design concept of the Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective is not intended to and shall not be effective to assign to Engineer any duty or authority to supervise or direct the performance of the Work, or any duty or authority to undertake responsibility contrary to the provisions of Article 10 or any other provision of the Contract Documents.

C. Day:

1. The word "day" means a calendar day of 24 hours measured from midnight to the next midnight.

D. Defective:

1. The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it:

a. does not conform to the Contract Documents; or

b. does not meet the requirements of any applicable inspection, reference standard, test, or approval referred to in the Contract Documents; or

c. has been damaged prior to Engineer's recommendation of final payment (unless responsibility for the protection thereof has been assumed by Owner at Substantial Completion in accordance with Paragraph 15.03 or 15.04).

E. Furnish, Install, Perform, Provide:

1. The word "furnish," when used in connection with services, materials, or equipment, shall mean to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.

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2. The word "install," when used in connection with services, materials, or equipment, shall mean to put into use or place in final position said services, materials, or equipment complete and ready for intended use.

3. The words "perform" or "provide," when used in connection with services, materials, or equipment, shall mean to furnish and install said services, materials, or equipment complete and ready for intended use.

4. If the Contract Documents establish an obligation of Contractor with respect to specific services, materials, or equipment, but do not expressly use any of the four words "furnish," "install," "perform," or "provide," then Contractor shall furnish and install said services, materials, or equipment complete and ready for intended use.

F. Unless stated otherwise in the Contract Documents, words or phrases that have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

ARTICLE 2 – PRELIMINARY MATTERS

2.01 *Delivery of Bonds and Evidence of Insurance*

A. *Bonds*: When Contractor delivers the executed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner such bonds as Contractor may be required to furnish.

B. *Evidence of Contractor's Insurance*: When Contractor delivers the executed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner, with copies to each named insured and additional insured (as identified in the Supplementary Conditions or elsewhere in the Contract), the certificates and other evidence of insurance required to be provided by Contractor in accordance with Article 6.

C. *Evidence of Owner's Insurance*: After receipt of the executed counterparts of the Agreement and all required bonds and insurance documentation, Owner shall promptly deliver to Contractor, with copies to each named insured and additional insured (as identified in the Supplementary Conditions or otherwise), the certificates and other evidence of insurance required to be provided by Owner under Article 6.

2.02 *Copies of Documents*

A. Owner shall furnish to Contractor four printed copies of the Contract (including one fully executed counterpart of the Agreement), and one copy in electronic portable document format (PDF). Additional printed copies will be furnished upon request at the cost of reproduction.

B. Owner shall maintain and safeguard at least one original printed record version of the Contract, including Drawings and Specifications signed and sealed by Engineer and other design professionals. Owner shall make such original printed record version of the Contract available to Contractor for review. Owner may delegate the responsibilities under this provision to Engineer.

2.03 *Before Starting Construction*

A. *Preliminary Schedules*: Within 10 days after the Effective Date of the Contract (or as otherwise specifically required by the Contract Documents), Contractor shall submit to Engineer for timely review:

1. a preliminary Progress Schedule indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract;

2. a preliminary Schedule of Submittals; and

3. a preliminary Schedule of Values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

2.04 *Preconstruction Conference; Designation of Authorized Representatives*

A. Before any Work at the Site is started, a conference attended by Owner, Contractor, Engineer, and others as appropriate will be held to establish a working understanding among the parties as to the Work and to discuss the schedules referred to in Paragraph

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2.03.A, procedures for handling Shop Drawings, Samples, and other submittals, processing Applications for Payment, electronic or digital transmittals, and maintaining required records.

B. At this conference Owner and Contractor each shall designate, in writing, a specific individual to act as its authorized representative with respect to the services and responsibilities under the Contract. Such individuals shall have the authority to transmit and receive information, render decisions relative to the Contract, and otherwise act on behalf of each respective party.

2.05 *Initial Acceptance of Schedules*

A. At least 10 days before submission of the first Application for Payment a conference, attended by Contractor, Engineer, and others as appropriate, will be held to review for acceptability to Engineer as provided below the schedules submitted in accordance with Paragraph 2.03.A. Contractor shall have an additional 10 days to make corrections and adjustments and to complete and resubmit the schedules. No progress payment shall be made to Contractor until acceptable schedules are submitted to Engineer.

1. The Progress Schedule will be acceptable to Engineer if it provides an orderly progression of the Work to completion within the Contract Times. Such acceptance will not impose on Engineer responsibility for the Progress Schedule, for sequencing, scheduling, or progress of the Work, nor interfere with or relieve Contractor from Contractor's full responsibility therefor.

2. Contractor's Schedule of Submittals will be acceptable to Engineer if it provides a workable arrangement for reviewing and processing the required submittals.

3. Contractor's Schedule of Values will be acceptable to Engineer as to form and substance if it provides a reasonable allocation of the Contract Price to the component parts of the Work.

2.06 *Electronic Transmittals*

A. Except as otherwise stated elsewhere in the Contract, the Owner, Engineer, and Contractor may transmit, and shall accept, Project-related correspondence, text, data, documents, drawings, information, and graphics, including but not limited to Shop Drawings and other submittals, in electronic media or digital format, either directly, or through access to a secure Project website.

B. If the Contract does not establish protocols for electronic or digital transmittals, then Owner, Engineer, and Contractor shall jointly develop such protocols.

C. When transmitting items in electronic media or digital format, the transmitting party makes no representations as to long term compatibility, usability, or readability of the items resulting from the recipient's use of software application packages, operating systems, or computer hardware differing from those used in the drafting or transmittal of the items, or from those established in applicable transmittal protocols.

ARTICLE 3 – DOCUMENTS: INTENT, REQUIREMENTS, REUSE

3.01 *Intent*

A. The Contract Documents are complementary; what is required by one is as binding as if required by all.

B. It is the intent of the Contract Documents to describe a functionally complete project (or part thereof) to be constructed in accordance with the Contract Documents.

C. Unless otherwise stated in the Contract Documents, if there is a discrepancy between the electronic or digital versions of the Contract Documents (including any printed copies derived from such electronic or digital versions) and the printed record version, the printed record version shall govern.

D. The Contract supersedes prior negotiations, representations, and agreements, whether written or oral.

E. Engineer will issue clarifications and interpretations of the Contract Documents as provided herein.

3.02 *Reference Standards*

A. Standards Specifications, Codes, Laws and Regulations

1. Reference in the Contract Documents to standard specifications, manuals, reference standards, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, shall mean the standard specification, manual, reference

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standard, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Contract if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

2. No provision of any such standard specification, manual, reference standard, or code, or any instruction of a Supplier, shall be effective to change the duties or responsibilities of Owner, Contractor, or Engineer, or any of their subcontractors, consultants, agents, or employees, from those set forth in the part of the Contract Documents prepared by or for Engineer. No such provision or instruction shall be effective to assign to Owner, Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility inconsistent with the provisions of the part of the Contract Documents prepared by or for Engineer.

3.03 *Reporting and Resolving Discrepancies*

A. Reporting Discrepancies:

1. *Contractor's Verification of Figures and Field Measurements*: Before undertaking each part of the Work, Contractor shall carefully study the Contract Documents, and check and verify pertinent figures and dimensions therein, particularly with respect to applicable field measurements. Contractor shall promptly report in writing to Engineer any conflict, error, ambiguity, or discrepancy that Contractor discovers, or has actual knowledge of, and shall not proceed with any Work affected thereby until the conflict, error, ambiguity, or discrepancy is resolved, by a clarification or interpretation by Engineer, or by an amendment or supplement to the Contract Documents issued pursuant to Paragraph 11.01.

2. *Contractor's Review of Contract Documents*: If, before or during the performance of the Work, Contractor discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents, or between the Contract Documents and (a) any applicable Law or Regulation, (b) actual field conditions, (c) any standard specification, manual, reference standard, or code, or (d) any instruction of any Supplier, then Contractor shall promptly report it to Engineer in writing. Contractor shall not proceed with the Work affected thereby (except in an emergency as required by Paragraph 7.15) until the conflict, error, ambiguity, or discrepancy is resolved, by a clarification or interpretation by Engineer, or by an amendment or supplement to the Contract Documents issued pursuant to Paragraph 11.01.

3. Contractor shall not be liable to Owner or Engineer for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless Contractor had actual knowledge thereof.

B. Resolving Discrepancies:

1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the part of the Contract Documents prepared by or for Engineer shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between such provisions of the Contract Documents and:

a. the provisions of any standard specification, manual, reference standard, or code, or the instruction of any Supplier (whether or not specifically incorporated by reference as a Contract Document); or

b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 *Requirements of the Contract Documents*

A. During the performance of the Work and until final payment, Contractor and Owner shall submit to the Engineer all matters in question concerning the requirements of the Contract Documents (sometimes referred to as requests for information or interpretation—RFIs), or relating to the acceptability of the Work under

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the Contract Documents, as soon as possible after such matters arise. Engineer will be the initial interpreter of the requirements of the Contract Documents, and judge of the acceptability of the Work thereunder.

B. Engineer will, with reasonable promptness, render a written clarification, interpretation, or decision on the issue submitted, or initiate an amendment or supplement to the Contract Documents. Engineer's written clarification, interpretation, or decision will be final and binding on Contractor, unless it appeals by submitting a Change Proposal, and on Owner, unless it appeals by filing a Claim.

C. If a submitted matter in question concerns terms and conditions of the Contract Documents that do not involve (1) the performance or acceptability of the Work under the Contract Documents, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, then Engineer will promptly give written notice to Owner and Contractor that Engineer is unable to provide a decision or interpretation. If Owner and Contractor are unable to agree on resolution of such a matter in question, either party may pursue resolution as provided in Article 12.

3.05 *Reuse of Documents*

A. Contractor and its Subcontractors and Suppliers shall not:

1. have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or its consultants, including electronic media editions, or reuse any such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of Owner and Engineer and specific written verification or adaptation by Engineer; or

2. have or acquire any title or ownership rights in any other Contract Documents, reuse any such Contract Documents for any purpose without Owner's express written consent, or violate any copyrights pertaining to such Contract Documents.

B. The prohibitions of this Paragraph 3.05 will survive final payment, or termination of the Contract. Nothing herein shall preclude Contractor from retaining copies of the Contract Documents for record purposes.

ARTICLE 4 – COMMENCEMENT AND PROGRESS OF THE WORK

4.01 *Commencement of Contract Times; Notice to Proceed*

A. The Contract Times will commence to run on the thirtieth day after the Effective Date of the Contract or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Contract. In no event will the Contract Times commence to run later than the sixtieth day after the day of Bid opening or the thirtieth day after the Effective Date of the Contract, whichever date is earlier.

4.02 *Starting the Work*

A. Contractor shall start to perform the Work on the date when the Contract Times commence to run. No Work shall be done at the Site prior to such date.

4.03 *Reference Points*

A. Owner shall provide engineering surveys to establish reference points for construction which in Engineer's judgment are necessary to enable Contractor to proceed with the Work. Contractor shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of Owner. Contractor shall report to Engineer whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.04 *Progress Schedule*

A. Contractor shall adhere to the Progress Schedule established in accordance with Paragraph 2.05 as it may be adjusted from time to time as provided below.

1. Contractor shall submit to Engineer for acceptance (to the extent indicated in Paragraph 2.05) proposed adjustments in the Progress Schedule that will not result in changing the Contract Times.

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2. Proposed adjustments in the Progress Schedule that will change the Contract Times shall be submitted in accordance with the requirements of Article 11.

B. Contractor shall carry on the Work and adhere to the Progress Schedule during all disputes or disagreements with Owner. No Work shall be delayed or postponed pending resolution of any disputes or disagreements, or during any appeal process, except as permitted by Paragraph 16.04, or as Owner and Contractor may otherwise agree in writing.

4.05 *Delays in Contractor's Progress*

A. If Owner, Engineer, or anyone for whom Owner is responsible, delays, disrupts, or interferes with the performance or progress of the Work, then Contractor shall be entitled to an equitable adjustment in the Contract Times and Contract Price. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times.

B. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for delay, disruption, or interference caused by or within the control of Contractor. Delay, disruption, and interference attributable to and within the control of a Subcontractor or Supplier shall be deemed to be within the control of Contractor.

C. If Contractor's performance or progress is delayed, disrupted, or interfered with by unanticipated causes not the fault of and beyond the control of Owner, Contractor, and those for which they are responsible, then Contractor shall be entitled to an equitable adjustment in Contract Times. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times. Such an adjustment shall be Contractor's sole and exclusive remedy for the delays, disruption, and interference described in this paragraph. Causes of delay, disruption, or interference that may give rise to an adjustment in Contract Times under this paragraph include but are not limited to the following:

1. severe and unavoidable natural catastrophes such as fires, floods, epidemics, and earthquakes;

2. abnormal weather conditions;

3. acts or failures to act of utility owners (other than those performing other work at or adjacent to the Site by arrangement with the Owner, as contemplated in Article 8); and

4. acts of war or terrorism.

D. Delays, disruption, and interference to the performance or progress of the Work resulting from the existence of a differing subsurface or physical condition, an Underground Facility that was not shown or indicated by the Contract Documents, or not shown or indicated with reasonable accuracy, and those resulting from Hazardous Environmental Conditions, are governed by Article 5.

E. Paragraph 8.03 governs delays, disruption, and interference to the performance or progress of the Work resulting from the performance of certain other work at or adjacent to the Site.

F. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for any delay, disruption, or interference if such delay is concurrent with a delay, disruption, or interference caused by or within the control of Contractor.

G. Contractor must submit any Change Proposal seeking an adjustment in Contract Price or Contract Times under this paragraph within 30 days of the commencement of the delaying, disrupting, or interfering event.

ARTICLE 5 – AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS

5.01 *Availability of Lands*

A. Owner shall furnish the Site. Owner shall notify Contractor of any encumbrances or restrictions not of general application but specifically related to use of the Site with which Contractor must comply in performing the Work.

B. Upon reasonable written request, Owner shall furnish Contractor with a current statement of record legal title and legal description of the lands upon which permanent improvements are to be made and Owner's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

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C. Contractor shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

5.02 *Use of Site and Other Areas*

A. Limitation on Use of Site and Other Areas:

1. Contractor shall confine construction equipment, temporary construction facilities, the storage of materials and equipment, and the operations of workers to the Site, adjacent areas that Contractor has arranged to use through construction easements or otherwise, and other adjacent areas permitted by Laws and Regulations, and shall not unreasonably encumber the Site and such other adjacent areas with construction equipment or other materials or equipment. Contractor shall assume full responsibility for (a) damage to the Site; (b) damage to any such other adjacent areas used for Contractor's operations; (c) damage to any other adjacent land or areas; and (d) for injuries and losses sustained by the owners or occupants of any such land or areas; provided that such damage or injuries result from the performance of the Work or from other actions or conduct of the Contractor or those for which Contractor is responsible.

2. If a damage or injury claim is made by the owner or occupant of any such land or area because of the performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible, Contractor shall (a) take immediate corrective or remedial action as required by Paragraph 7.12, or otherwise; (b) promptly attempt to settle the claim as to all parties through negotiations with such owner or occupant, or otherwise resolve the claim by arbitration or other dispute resolution proceeding, or at law; and (c) to the fullest extent permitted by Laws and Regulations, indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against any such claim, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against Owner, Engineer, or any other party indemnified hereunder to the extent caused directly or indirectly, in whole or in part by, or based upon, Contractor's performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible.

B. *Removal of Debris During Performance of the Work*: During the progress of the Work the Contractor shall keep the Site and other adjacent areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris shall conform to applicable Laws and Regulations.

C. *Cleaning*: Prior to Substantial Completion of the Work Contractor shall clean the Site and the Work and make it ready for utilization by Owner. At the completion of the Work Contractor shall remove from the Site and adjacent areas all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading of Structures*: Contractor shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall Contractor subject any part of the Work or adjacent structures or land to stresses or pressures that will endanger them.

5.03 *Subsurface and Physical Conditions*

A. *Reports and Drawings*: The Supplementary Conditions identify:

1. those reports known to Owner of explorations and tests of subsurface conditions at or adjacent to the Site;

2. those drawings known to Owner of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities); and

3. Technical Data contained in such reports and drawings.

B. *Reliance by Contractor on Technical Data Authorized*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions

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with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely upon the accuracy of the Technical Data (as defined in Article 1) contained in any geotechnical or environmental report prepared for the Project and made available to Contractor. Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto; or
2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or
3. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions, or information.

5.04 *Differing Subsurface or Physical Conditions*

A. *Notice by Contractor*: If Contractor believes that any subsurface or physical condition that is uncovered or revealed at the Site either:

1. is of such a nature as to establish that any Technical Data on which Contractor is entitled to rely as provided in Paragraph 5.03 is materially inaccurate; or
2. is of such a nature as to require a change in the Drawings or Specifications; or
3. differs materially from that shown or indicated in the Contract Documents; or
4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents;

then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or perform any Work in connection therewith (except with respect to an emergency) until receipt of a written statement permitting Contractor to do so.

B. *Engineer's Review*: After receipt of written notice as required by the preceding paragraph, Engineer will promptly review the subsurface or physical condition in question; determine the necessity of Owner's obtaining additional exploration or tests with respect to the condition; conclude whether the condition falls within any one or more of the differing site condition categories in Paragraph 5.04.A above; obtain any pertinent cost or schedule information from Contractor; prepare recommendations to Owner regarding the Contractor's resumption of Work in connection with the subsurface or physical condition in question and the need for any change in the Drawings or Specifications; and advise Owner in writing of Engineer's findings, conclusions, and recommendations.

C. *Owner's Statement to Contractor Regarding Site Condition*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the subsurface or physical condition in question, addressing the resumption of Work in connection with such condition, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations, in whole or in part.

D. Possible Price and Times Adjustments:

1. Contractor shall be entitled to an equitable adjustment in Contract Price or Contract Times, or both, to the extent that the existence of a differing subsurface or physical condition, or any related delay, disruption, or interference, causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:
    a. such condition must fall within any one or more of the categories described in Paragraph 5.04.A;
    b. with respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will

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be subject to the provisions of Paragraph 13.03; and,

c. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times.

2. Contractor shall not be entitled to any adjustment in the Contract Price or Contract Times with respect to a subsurface or physical condition if:

a. Contractor knew of the existence of such condition at the time Contractor made a commitment to Owner with respect to Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract, or otherwise; or

b. the existence of such condition reasonably could have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas expressly required by the Bidding Requirements or Contract Documents to be conducted by or for Contractor prior to Contractor's making such commitment; or

c. Contractor failed to give the written notice as required by Paragraph 5.04.A.

3. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, or both, then any such adjustment shall be set forth in a Change Order.

4. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, or both, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the subsurface or physical condition in question.

5.05 *Underground Facilities*

A. *Contractor's Responsibilities*: The information and data shown or indicated in the Contract Documents with respect to existing Underground Facilities at or adjacent to the Site is based on information and data furnished to Owner or Engineer by the owners of such Underground Facilities, including Owner, or by others. Unless it is otherwise expressly provided in the Supplementary Conditions:

1. Owner and Engineer do not warrant or guarantee the accuracy or completeness of any such information or data provided by others; and

2. the cost of all of the following will be included in the Contract Price, and Contractor shall have full responsibility for:

a. reviewing and checking all information and data regarding existing Underground Facilities at the Site;

b. locating all Underground Facilities shown or indicated in the Contract Documents as being at the Site;

c. coordination of the Work with the owners (including Owner) of such Underground Facilities, during construction; and

d. the safety and protection of all existing Underground Facilities at the Site, and repairing any damage thereto resulting from the Work.

B. *Notice by Contractor*: If Contractor believes that an Underground Facility that is uncovered or revealed at the Site was not shown or indicated in the Contract Documents, or was not shown or indicated with reasonable accuracy, then Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), identify the owner of such Underground Facility and give written notice to that owner and to Owner and Engineer.

C. *Engineer's Review*: Engineer will promptly review the Underground Facility and conclude whether such Underground Facility was not shown or indicated in the Contract Documents, or was not shown or indicated with reasonable accuracy; obtain any pertinent cost or schedule information from Contractor; prepare recommendations to Owner regarding the Contractor's resumption of Work in connection with the Underground Facility in question; determine the extent, if any, to

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which a change is required in the Drawings or Specifications to reflect and document the consequences of the existence or location of the Underground Facility; and advise Owner in writing of Engineer's findings, conclusions, and recommendations. During such time, Contractor shall be responsible for the safety and protection of such Underground Facility.

D. *Owner's Statement to Contractor Regarding Underground Facility*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the Underground Facility in question, addressing the resumption of Work in connection with such Underground Facility, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations in whole or in part.

E. Possible Price and Times Adjustments:

1. Contractor shall be entitled to an equitable adjustment in the Contract Price or Contract Times, or both, to the extent that any existing Underground Facility at the Site that was not shown or indicated in the Contract Documents, or was not shown or indicated with reasonable accuracy, or any related delay, disruption, or interference, causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:

a. Contractor did not know of and could not reasonably have been expected to be aware of or to have anticipated the existence or actual location of the Underground Facility in question;

b. With respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraph 13.03;

c. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times; and

d. Contractor gave the notice required in Paragraph 5.05.B.

2. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, or both, then any such adjustment shall be set forth in a Change Order.

3. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, or both, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the Underground Facility in question.

5.06 *Hazardous Environmental Conditions at Site*

A. *Reports and Drawings*: The Supplementary Conditions identify:

1. those reports and drawings known to Owner relating to Hazardous Environmental Conditions that have been identified at or adjacent to the Site; and

2. Technical Data contained in such reports and drawings.

B. *Reliance by Contractor on Technical Data Authorized*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely on the accuracy of the Technical Data (as defined in Article 1) contained in any geotechnical or environmental report prepared for the Project and made available to Contractor. Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures of construction to be employed by Contractor and safety precautions and programs incident thereto; or

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2. other data, interpretations, opinions and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions or information.

C. Contractor shall not be responsible for removing or remediating any Hazardous Environmental Condition encountered, uncovered, or revealed at the Site unless such removal or remediation is expressly identified in the Contract Documents to be within the scope of the Work.

D. Contractor shall be responsible for controlling, containing, and duly removing all Constituents of Concern brought to the Site by Contractor, Subcontractors, Suppliers, or anyone else for whom Contractor is responsible, and for any associated costs; and for the costs of removing and remediating any Hazardous Environmental Condition created by the presence of any such Constituents of Concern.

E. If Contractor encounters, uncovers, or reveals a Hazardous Environmental Condition whose removal or remediation is not expressly identified in the Contract Documents as being within the scope of the Work, or if Contractor or anyone for whom Contractor is responsible creates a Hazardous Environmental Condition, then Contractor shall immediately: (1) secure or otherwise isolate such condition; (2) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by Paragraph 7.15); and (3) notify Owner and Engineer (and promptly thereafter confirm such notice in writing). Owner shall promptly consult with Engineer concerning the necessity for Owner to retain a qualified expert to evaluate such condition or take corrective action, if any. Promptly after consulting with Engineer, Owner shall take such actions as are necessary to permit Owner to timely obtain required permits and provide Contractor the written notice required by Paragraph 5.06.F. If Contractor or anyone for whom Contractor is responsible created the Hazardous Environmental Condition in question, then Owner may remove and remediate the Hazardous Environmental Condition, and impose a set-off against payments to account for the associated costs.

F. Contractor shall not resume Work in connection with such Hazardous Environmental Condition or in any affected area until after Owner has obtained any required permits related thereto, and delivered written notice to Contractor either (1) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work, or (2) specifying any special conditions under which such Work may be resumed safely.

G. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, or both, as a result of such Work stoppage or such special conditions under which Work is agreed to be resumed by Contractor, then within 30 days of Owner's written notice regarding the resumption of Work, Contractor may submit a Change Proposal, or Owner may impose a set-off.

H. If after receipt of such written notice Contractor does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then Owner may order the portion of the Work that is in the area affected by such condition to be deleted from the Work, following the contractual change procedures in Article 11. Owner may have such deleted portion of the Work performed by Owner's own forces or others in accordance with Article 8.

I. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition (1) was not shown or indicated in the Drawings, Specifications, or other Contract Documents, identified as Technical Data entitled to limited reliance pursuant to Paragraph 5.06.B, or identified in the Contract Documents to be included within the scope of the Work, and (2) was not created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.H shall obligate Owner

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to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

J. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the failure to control, contain, or remove a Constituent of Concern brought to the Site by Contractor or by anyone for whom Contractor is responsible, or to a Hazardous Environmental Condition created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.J shall obligate Contractor to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

K. The provisions of Paragraphs 5.03, 5.04, and 5.05 do not apply to the presence of Constituents of Concern or to a Hazardous Environmental Condition uncovered or revealed at the Site.

ARTICLE 6 – BONDS AND INSURANCE

6.01 *Performance, Payment, and Other Bonds*

A. Contractor shall furnish a performance bond and a payment bond, each in an amount at least equal to the Contract Price, as security for the faithful performance and payment of all of Contractor's obligations under the Contract. These bonds shall remain in effect until one year after the date when final payment becomes due or until completion of the correction period specified in Paragraph 15.08, whichever is later, except as provided otherwise by Laws or Regulations, the Supplementary Conditions, or other specific provisions of the Contract. Contractor shall also furnish such other bonds as are required by the Supplementary Conditions or other specific provisions of the Contract.

B. All bonds shall be in the form prescribed by the Contract except as provided otherwise by Laws or Regulations, and shall be executed by such sureties as are named in "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 (as amended and supplemented) by the Financial Management Service, Surety Bond Branch, U.S. Department of the Treasury. A bond signed by an agent or attorney-in-fact must be accompanied by a certified copy of that individual's authority to bind the surety. The evidence of authority shall show that it is effective on the date the agent or attorney-in-fact signed the accompanying bond.

C. Contractor shall obtain the required bonds from surety companies that are duly licensed or authorized in the jurisdiction in which the Project is located to issue bonds in the required amounts.

D. If the surety on a bond furnished by Contractor is declared bankrupt or becomes insolvent, or its right to do business is terminated in any state or jurisdiction where any part of the Project is located, or the surety ceases to meet the requirements above, then Contractor shall promptly notify Owner and Engineer and shall, within 20 days after the event giving rise to such notification, provide another bond and surety, both of which shall comply with the bond and surety requirements above.

E. If Contractor has failed to obtain a required bond, Owner may exclude the Contractor from the Site and exercise Owner's termination rights under Article 16.

F. Upon request, Owner shall provide a copy of the payment bond to any Subcontractor, Supplier, or other person or entity claiming to have furnished labor or materials used in the performance of the Work.

6.02 *Insurance—General Provisions*

A. Owner and Contractor shall obtain and maintain insurance as required in this Article and in the Supplementary Conditions.

B. All insurance required by the Contract to be purchased and maintained by Owner or Contractor shall be obtained from insurance companies that are duly licensed or authorized, in the state or jurisdiction in which the Project is located, to issue insurance policies for the required limits and coverages. Unless a different standard is indicated in the Supplementary Conditions, all companies that provide insurance policies required under this Contract shall have an A.M. Best rating of A-VII or better.

C. Contractor shall deliver to Owner, with copies to each named insured and additional insured

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(as identified in this Article, in the Supplementary Conditions, or elsewhere in the Contract), certificates of insurance establishing that Contractor has obtained and is maintaining the policies, coverages, and endorsements required by the Contract. Upon request by Owner or any other insured, Contractor shall also furnish other evidence of such required insurance, including but not limited to copies of policies and endorsements, and documentation of applicable self-insured retentions and deductibles. Contractor may block out (redact) any confidential premium or pricing information contained in any policy or endorsement furnished under this provision.

D. Owner shall deliver to Contractor, with copies to each named insured and additional insured (as identified in this Article, the Supplementary Conditions, or elsewhere in the Contract), certificates of insurance establishing that Owner has obtained and is maintaining the policies, coverages, and endorsements required of Owner by the Contract (if any). Upon request by Contractor or any other insured, Owner shall also provide other evidence of such required insurance (if any), including but not limited to copies of policies and endorsements, and documentation of applicable self-insured retentions and deductibles. Owner may block out (redact) any confidential premium or pricing information contained in any policy or endorsement furnished under this provision.

E. Failure of Owner or Contractor to demand such certificates or other evidence of the other party's full compliance with these insurance requirements, or failure of Owner or Contractor to identify a deficiency in compliance from the evidence provided, shall not be construed as a waiver of the other party's obligation to obtain and maintain such insurance.

F. If either party does not purchase or maintain all of the insurance required of such party by the Contract, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage.

G. If Contractor has failed to obtain and maintain required insurance, Owner may exclude the Contractor from the Site, impose an appropriate set-off against payment, and exercise Owner's termination rights under Article 16.

H. Without prejudice to any other right or remedy, if a party has failed to obtain required insurance, the other party may elect to obtain equivalent insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and the Contract Price shall be adjusted accordingly.

I. Owner does not represent that insurance coverage and limits established in this Contract necessarily will be adequate to protect Contractor or Contractor's interests.

J. The insurance and insurance limits required herein shall not be deemed as a limitation on Contractor's liability under the indemnities granted to Owner and other individuals and entities in the Contract.

6.03 *Contractor's Insurance*

A. *Workers' Compensation*: Contractor shall purchase and maintain workers' compensation and employer's liability insurance for:

1. claims under workers' compensation, disability benefits, and other similar employee benefit acts.

2. United States Longshoreman and Harbor Workers' Compensation Act and Jones Act coverage (if applicable).

3. claims for damages because of bodily injury, occupational sickness or disease, or death of Contractor's employees (by stop-gap endorsement in monopolist worker's compensation states).

4. Foreign voluntary worker compensation (if applicable).

B. *Commercial General Liability—Claims Covered*: Contractor shall purchase and maintain commercial general liability insurance, covering all operations by or on behalf of Contractor, on an occurrence basis, against:

1. claims for damages because of bodily injury, sickness or disease, or death of any person other than Contractor's employees.

2. claims for damages insured by reasonably available personal injury liability coverage.

3. claims for damages, other than to the Work itself, because of injury to or destruction of tangible property

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wherever located, including loss of use resulting therefrom.

C. *Commercial General Liability—Form and Content*: Contractor's commercial liability policy shall be written on a 1996 (or later) ISO commercial general liability form (occurrence form) and include the following coverages and endorsements:

1. Products and completed operations coverage:
    a. Such insurance shall be maintained for three years after final payment.
    b. Contractor shall furnish Owner and each other additional insured (as identified in the Supplementary Conditions or elsewhere in the Contract) evidence of continuation of such insurance at final payment and three years thereafter.
2. Blanket contractual liability coverage, to the extent permitted by law, including but not limited to coverage of Contractor's contractual indemnity obligations in Paragraph 7.18.
3. Broad form property damage coverage.
4. Severability of interest.
5. Underground, explosion, and collapse coverage.
6. Personal injury coverage.
7. Additional insured endorsements that include both ongoing operations and products and completed operations coverage through ISO Endorsements CG 20 10 10 01 and CG 20 37 10 01 (together); or CG 20 10 07 04 and CG 20 37 07 04 (together); or their equivalent.
8. For design professional additional insureds, ISO Endorsement CG 20 32 07 04, "Additional Insured—Engineers, Architects or Surveyors Not Engaged by the Named Insured" or its equivalent.

D. *Automobile liability*: Contractor shall purchase and maintain automobile liability insurance against claims for damages because of bodily injury or death of any person or property damage arising out of the ownership, maintenance, or use of any motor vehicle. The automobile liability policy shall be written on an occurrence basis.

E. *Umbrella or excess liability*: Contractor shall purchase and maintain umbrella or excess liability insurance written over the underlying employer's liability, commercial general liability, and automobile liability insurance described in the paragraphs above. Subject to industry-standard exclusions, the coverage afforded shall follow form as to each and every one of the underlying policies.

F. *Contractor's pollution liability insurance*: Contractor shall purchase and maintain a policy covering third-party injury and property damage claims, including clean-up costs, as a result of pollution conditions arising from Contractor's operations and completed operations. This insurance shall be maintained for no less than three years after final completion.

G. *Additional insureds*: The Contractor's commercial general liability, automobile liability, umbrella or excess, and pollution liability policies shall include and list as additional insureds Owner and Engineer, and any individuals or entities identified in the Supplementary Conditions; include coverage for the respective officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of all such additional insureds; and the insurance afforded to these additional insureds shall provide primary coverage for all claims covered thereby (including as applicable those arising from both ongoing and completed operations) on a non-contributory basis. Contractor shall obtain all necessary endorsements to support these requirements.

H. *Contractor's professional liability insurance*: If Contractor will provide or furnish professional services under this Contract, through a delegation of professional design services or otherwise, then Contractor shall be responsible for purchasing and maintaining applicable professional liability insurance. This insurance shall provide protection against claims arising out of performance of professional design or related services, and caused by a negligent error, omission, or act for which the insured party is legally liable. It shall be maintained throughout the duration of the Contract and for a minimum of two years after Substantial Completion. If such professional design services are performed by a Subcontractor, and not by Contractor itself, then the requirements of this paragraph may be satisfied through the purchasing and maintenance of such insurance by such Subcontractor.

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I. *General provisions*: The policies of insurance required by this Paragraph 6.03 shall:

1. include at least the specific coverages provided in this Article.

2. be written for not less than the limits of liability provided in this Article and in the Supplementary Conditions, or required by Laws or Regulations, whichever is greater.

3. contain a provision or endorsement that the coverage afforded will not be canceled, materially changed, or renewal refused until at least 10 days prior written notice has been given to Contractor. Within three days of receipt of any such written notice, Contractor shall provide a copy of the notice to Owner, Engineer, and each other insured under the policy.

4. remain in effect at least until final payment (and longer if expressly required in this Article) and at all times thereafter when Contractor may be correcting, removing, or replacing defective Work as a warranty or correction obligation, or otherwise, or returning to the Site to conduct other tasks arising from the Contract Documents.

5. be appropriate for the Work being performed and provide protection from claims that may arise out of or result from Contractor's performance of the Work and Contractor's other obligations under the Contract Documents, whether it is to be performed by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable.

J. The coverage requirements for specific policies of insurance must be met by such policies, and not by reference to excess or umbrella insurance provided in other policies.

6.04 *Owner's Liability Insurance*

A. In addition to the insurance required to be provided by Contractor under Paragraph 6.03, Owner, at Owner's option, may purchase and maintain at Owner's expense Owner's own liability insurance as will protect Owner against claims which may arise from operations under the Contract Documents.

B. Owner's liability policies, if any, operate separately and independently from policies required to be provided by Contractor, and Contractor cannot rely upon Owner's liability policies for any of Contractor's obligations to the Owner, Engineer, or third parties.

6.05 *Property Insurance*

A. *Builder's Risk*: Unless otherwise provided in the Supplementary Conditions, Contractor shall purchase and maintain builder's risk insurance upon the Work on a completed value basis, in the amount of the full insurable replacement cost thereof (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). This insurance shall:

1. include the Owner and Contractor as named insureds, and all Subcontractors, and any individuals or entities required by the Supplementary Conditions to be insured under such builder's risk policy, as insureds or named insureds. For purposes of the remainder of this Paragraph 6.05, Paragraphs 6.06 and 6.07, and any corresponding Supplementary Conditions, the parties required to be insured shall collectively be referred to as "insureds."

2. be written on a builder's risk "all risk" policy form that shall at least include insurance for physical loss or damage to the Work, temporary buildings, falsework, and materials and equipment in transit, and shall insure against at least the following perils or causes of loss: fire; lightning; windstorm; riot; civil commotion; terrorism; vehicle impact; aircraft; smoke; theft; vandalism and malicious mischief; mechanical breakdown, boiler explosion, and artificially generated electric current; earthquake; volcanic activity, and other earth movement; flood; collapse; explosion; debris removal; demolition occasioned by enforcement of Laws and Regulations; water damage (other than that caused by flood); and such other perils or causes of loss as may be specifically required by the Supplementary Conditions. If insurance against mechanical breakdown, boiler explosion, and artificially generated electric current; earthquake; volcanic activity, and other earth movement; or flood, are not commercially available under builder's risk policies, by

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endorsement or otherwise, such insurance may be provided through other insurance policies acceptable to Owner and Contractor.

3. cover, as insured property, at least the following: (a) the Work and all materials, supplies, machinery, apparatus, equipment, fixtures, and other property of a similar nature that are to be incorporated into or used in the preparation, fabrication, construction, erection, or completion of the Work, including Owner-furnished or assigned property; (b) spare parts inventory required within the scope of the Contract; and (c) temporary works which are not intended to form part of the permanent constructed Work but which are intended to provide working access to the Site, or to the Work under construction, or which are intended to provide temporary support for the Work under construction, including scaffolding, form work, fences, shoring, falsework, and temporary structures.

4. cover expenses incurred in the repair or replacement of any insured property (including but not limited to fees and charges of engineers and architects).

5. extend to cover damage or loss to insured property while in temporary storage at the Site or in a storage location outside the Site (but not including property stored at the premises of a manufacturer or Supplier).

6. extend to cover damage or loss to insured property while in transit.

7. allow for partial occupation or use of the Work by Owner, such that those portions of the Work that are not yet occupied or used by Owner shall remain covered by the builder's risk insurance.

8. allow for the waiver of the insurer's subrogation rights, as set forth below.

9. provide primary coverage for all losses and damages caused by the perils or causes of loss covered.

10. not include a co-insurance clause.

11. include an exception for ensuing losses from physical damage or loss with respect to any defective workmanship, design, or materials exclusions.

12. include performance/hot testing and start-up.

13. be maintained in effect, subject to the provisions herein regarding Substantial Completion and partial occupancy or use of the Work by Owner, until the Work is complete.

B. *Notice of Cancellation or Change*: All the policies of insurance (and the certificates or other evidence thereof) required to be purchased and maintained in accordance with this Paragraph 6.05 will contain a provision or endorsement that the coverage afforded will not be canceled or materially changed or renewal refused until at least 10 days prior written notice has been given to the purchasing policyholder. Within three days of receipt of any such written notice, the purchasing policyholder shall provide a copy of the notice to each other insured.

C. *Deductibles*: The purchaser of any required builder's risk or property insurance shall pay for costs not covered because of the application of a policy deductible.

D. *Partial Occupancy or Use by Owner*: If Owner will occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work as provided in Paragraph 15.04, then Owner (directly, if it is the purchaser of the builder's risk policy, or through Contractor) will provide notice of such occupancy or use to the builder's risk insurer. The builder's risk insurance shall not be canceled or permitted to lapse on account of any such partial use or occupancy; rather, those portions of the Work that are occupied or used by Owner may come off the builder's risk policy, while those portions of the Work not yet occupied or used by Owner shall remain covered by the builder's risk insurance.

E. *Additional Insurance*: If Contractor elects to obtain other special insurance to be included in or supplement the builder's risk or property insurance policies provided under this Paragraph 6.05, it may do so at Contractor's expense.

F. *Insurance of Other Property*: If the express insurance provisions of the Contract do not require or address the insurance of a property item or interest, such as tools, construction equipment, or other personal property owned by Contractor, a Subcontractor, or an employee of Contractor or a Subcontractor, then the entity or individual owning such

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property item will be responsible for deciding whether to insure it, and if so in what amount.

6.06 *Waiver of Rights*

A. All policies purchased in accordance with Paragraph 6.05, expressly including the builder's risk policy, shall contain provisions to the effect that in the event of payment of any loss or damage the insurers will have no rights of recovery against any insureds thereunder, or against Engineer or its consultants, or their officers, directors, members, partners, employees, agents, consultants, or subcontractors. Owner and Contractor waive all rights against each other and the respective officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Engineer, its consultants, all Subcontractors, all individuals or entities identified in the Supplementary Conditions as insureds, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, under such policies for losses and damages so caused. None of the above waivers shall extend to the rights that any party making such waiver may have to the proceeds of insurance held by Owner or Contractor as trustee or fiduciary, or otherwise payable under any policy so issued.

B. Owner waives all rights against Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, for:

1. loss due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to Owner's property or the Work caused by, arising out of, or resulting from fire or other perils whether or not insured by Owner; and

2. loss or damage to the completed Project or part thereof caused by, arising out of, or resulting from fire or other insured peril or cause of loss covered by any property insurance maintained on the completed Project or part thereof by Owner during partial occupancy or use pursuant to Paragraph 15.04, after Substantial Completion pursuant to Paragraph 15.03, or after final payment pursuant to Paragraph 15.06.

C. Any insurance policy maintained by Owner covering any loss, damage or consequential loss referred to in Paragraph 6.06.B shall contain provisions to the effect that in the event of payment of any such loss, damage, or consequential loss, the insurers will have no rights of recovery against Contractor, Subcontractors, or Engineer, or the officers, directors, members, partners, employees, agents, consultants, or subcontractors of each and any of them.

D. Contractor shall be responsible for assuring that the agreement under which a Subcontractor performs a portion of the Work contains provisions whereby the Subcontractor waives all rights against Owner, Contractor, all individuals or entities identified in the Supplementary Conditions as insureds, the Engineer and its consultants, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, relating to, or resulting from any of the perils or causes of loss covered by builder's risk insurance and any other property insurance applicable to the Work.

6.07 *Receipt and Application of Property Insurance Proceeds*

A. Any insured loss under the builder's risk and other policies of insurance required by Paragraph 6.05 will be adjusted and settled with the named insured that purchased the policy. Such named insured shall act as fiduciary for the other insureds, and give notice to such other insureds that adjustment and settlement of a claim is in progress. Any other insured may state its position regarding a claim for insured loss in writing within 15 days after notice of such claim.

B. Proceeds for such insured losses may be made payable by the insurer either jointly to multiple insureds, or to the named insured that purchased the policy in its own right and as fiduciary for other insureds, subject to the requirements of any applicable mortgage clause. A named insured receiving insurance proceeds under the builder's risk and other policies of insurance required by Paragraph 6.05 shall distribute such proceeds in accordance with such agreement as the parties in interest may reach, or as otherwise required

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under the dispute resolution provisions of this Contract or applicable Laws and Regulations.

C. If no other special agreement is reached, the damaged Work shall be repaired or replaced, the money so received applied on account thereof, and the Work and the cost thereof covered by Change Order, if needed.

ARTICLE 7 – CONTRACTOR'S RESPONSIBILITIES

7.01 *Supervision and Superintendence*

A. Contractor shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents. Contractor shall be solely responsible for the means, methods, techniques, sequences, and procedures of construction.

B. At all times during the progress of the Work, Contractor shall assign a competent resident superintendent who shall not be replaced without written notice to Owner and Engineer except under extraordinary circumstances.

7.02 *Labor; Working Hours*

A. Contractor shall provide competent, suitably qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. Contractor shall at all times maintain good discipline and order at the Site.

B. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site shall be performed during regular working hours, Monday through Friday. Contractor will not perform Work on a Saturday, Sunday, or any legal holiday. Contractor may perform Work outside regular working hours or on Saturdays, Sundays, or legal holidays only with Owner's written consent, which will not be unreasonably withheld.

7.03 *Services, Materials, and Equipment*

A. Unless otherwise specified in the Contract Documents, Contractor shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start up, and completion of the Work, whether or not such items are specifically called for in the Contract Documents.

B. All materials and equipment incorporated into the Work shall be of good quality and new, except as otherwise provided in the Contract Documents. All special warranties and guarantees required by the Specifications shall expressly run to the benefit of Owner. If required by Engineer, Contractor shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment.

C. All materials and equipment shall be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

7.04 *"Or Equals"*

A. Whenever an item of material or equipment is specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular Supplier, the Contract Price has been based upon Contractor furnishing such item as specified. The specification or description of such an item is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or equal" item is permitted, Contractor may request that Engineer authorize the use of other items of material or equipment, or items from other proposed suppliers under the circumstances described below.

1. If Engineer in its sole discretion determines that an item of material or equipment proposed by Contractor is functionally equal to that named and sufficiently similar so that no change in related Work will be required, Engineer shall deem it an "or equal" item. For the purposes of this paragraph, a proposed item of material or equipment will be considered functionally equal to an item so named if:

    a. in the exercise of reasonable judgment Engineer determines that:

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1) it is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics;

2) it will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole;

3) it has a proven record of performance and availability of responsive service; and

4) it is not objectionable to Owner.

b. Contractor certifies that, if approved and incorporated into the Work:

1) there will be no increase in cost to the Owner or increase in Contract Times; and

2) it will conform substantially to the detailed requirements of the item named in the Contract Documents.

B. *Contractor's Expense*: Contractor shall provide all data in support of any proposed "or equal" item at Contractor's expense.

C. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each "or-equal" request. Engineer may require Contractor to furnish additional data about the proposed "or-equal" item. Engineer will be the sole judge of acceptability. No "or-equal" item will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an "or-equal", which will be evidenced by an approved Shop Drawing or other written communication. Engineer will advise Contractor in writing of any negative determination.

D. *Effect of Engineer's Determination*: Neither approval nor denial of an "or-equal" request shall result in any change in Contract Price. The Engineer's denial of an "or-equal" request shall be final and binding, and may not be reversed through an appeal under any provision of the Contract Documents.

E. *Treatment as a Substitution Request*: If Engineer determines that an item of material or equipment proposed by Contractor does not qualify as an "or-equal" item, Contractor may request that Engineer considered the proposed item as a substitute pursuant to Paragraph 7.05.

7.05 *Substitutes*

A. Unless the specification or description of an item of material or equipment required to be furnished under the Contract Documents contains or is followed by words reading that no substitution is permitted, Contractor may request that Engineer authorize the use of other items of material or equipment under the circumstances described below. To the extent possible such requests shall be made before commencement of related construction at the Site.

1. Contractor shall submit sufficient information as provided below to allow Engineer to determine if the item of material or equipment proposed is functionally equivalent to that named and an acceptable substitute therefor. Engineer will not accept requests for review of proposed substitute items of material or equipment from anyone other than Contractor.

2. The requirements for review by Engineer will be as set forth in Paragraph 7.05.B, as supplemented by the Specifications, and as Engineer may decide is appropriate under the circumstances.

3. Contractor shall make written application to Engineer for review of a proposed substitute item of material or equipment that Contractor seeks to furnish or use. The application:

a. shall certify that the proposed substitute item will:

1) perform adequately the functions and achieve the results called for by the general design,

2) be similar in substance to that specified, and

3) be suited to the same use as that specified.

b. will state:

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1) the extent, if any, to which the use of the proposed substitute item will necessitate a change in Contract Times,

2) whether use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item, and

3) whether incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty.

c. will identify:

1) all variations of the proposed substitute item from that specified, and

2) available engineering, sales, maintenance, repair, and replacement services.

d. shall contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including but not limited to changes in Contract Price, shared savings, costs of redesign, and claims of other contractors affected by any resulting change.

B. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each substitute request, and to obtain comments and direction from Owner. Engineer may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No substitute will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an acceptable substitute. Engineer's determination will be evidenced by a Field Order or a proposed Change Order accounting for the substitution itself and all related impacts, including changes in Contract Price or Contract Times. Engineer will advise Contractor in writing of any negative determination.

C. *Special Guarantee*: Owner may require Contractor to furnish at Contractor's expense a special performance guarantee or other surety with respect to any substitute.

D. *Reimbursement of Engineer's Cost*: Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor. Whether or not Engineer approves a substitute so proposed or submitted by Contractor, Contractor shall reimburse Owner for the reasonable charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the reasonable charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

E. *Contractor's Expense*: Contractor shall provide all data in support of any proposed substitute at Contractor's expense.

F. *Effect of Engineer's Determination*: If Engineer approves the substitution request, Contractor shall execute the proposed Change Order and proceed with the substitution. The Engineer's denial of a substitution request shall be final and binding, and may not be reversed through an appeal under any provision of the Contract Documents. Contractor may challenge the scope of reimbursement costs imposed under Paragraph 7.05.D, by timely submittal of a Change Proposal.

7.06 *Concerning Subcontractors, Suppliers, and Others*

A. Contractor may retain Subcontractors and Suppliers for the performance of parts of the Work. Such Subcontractors and Suppliers must be acceptable to Owner.

B. Contractor shall retain specific Subcontractors, Suppliers, or other individuals or entities for the performance of designated parts of the Work if required by the Contract to do so.

C. Subsequent to the submittal of Contractor's Bid or final negotiation of the terms of the Contract, Owner may not require Contractor to retain any Subcontractor, Supplier, or other individual or entity to furnish or perform any of the Work against which Contractor has reasonable objection.

D. Prior to entry into any binding subcontract or purchase order, Contractor shall submit to Owner the identity of the proposed Subcontractor or Supplier (unless Owner has

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already deemed such proposed Subcontractor or Supplier acceptable, during the bidding process or otherwise). Such proposed Subcontractor or Supplier shall be deemed acceptable to Owner unless Owner raises a substantive, reasonable objection within five days.

E. Owner may require the replacement of any Subcontractor, Supplier, or other individual or entity retained by Contractor to perform any part of the Work. Owner also may require Contractor to retain specific replacements; provided, however, that Owner may not require a replacement to which Contractor has a reasonable objection. If Contractor has submitted the identity of certain Subcontractors, Suppliers, or other individuals or entities for acceptance by Owner, and Owner has accepted it (either in writing or by failing to make written objection thereto), then Owner may subsequently revoke the acceptance of any such Subcontractor, Supplier, or other individual or entity so identified solely on the basis of substantive, reasonable objection after due investigation. Contractor shall submit an acceptable replacement for the rejected Subcontractor, Supplier, or other individual or entity.

F. If Owner requires the replacement of any Subcontractor, Supplier, or other individual or entity retained by Contractor to perform any part of the Work, then Contractor shall be entitled to an adjustment in Contract Price or Contract Times, or both, with respect to the replacement; and Contractor shall initiate a Change Proposal for such adjustment within 30 days of Owner's requirement of replacement.

G. No acceptance by Owner of any such Subcontractor, Supplier, or other individual or entity, whether initially or as a replacement, shall constitute a waiver of the right of Owner to the completion of the Work in accordance with the Contract Documents.

H. On a monthly basis Contractor shall submit to Engineer a complete list of all Subcontractors and Suppliers having a direct contract with Contractor, and of all other Subcontractors and Suppliers known to Contractor at the time of submittal.

I. Contractor shall be fully responsible to Owner and Engineer for all acts and omissions of the Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work just as Contractor is responsible for Contractor's own acts and omissions.

J. Contractor shall be solely responsible for scheduling and coordinating the work of Subcontractors, Suppliers, and all other individuals or entities performing or furnishing any of the Work.

K. Contractor shall restrict all Subcontractors, Suppliers, and such other individuals or entities performing or furnishing any of the Work from communicating with Engineer or Owner, except through Contractor or in case of an emergency, or as otherwise expressly allowed herein.

L. The divisions and sections of the Specifications and the identifications of any Drawings shall not control Contractor in dividing the Work among Subcontractors or Suppliers or delineating the Work to be performed by any specific trade.

M. All Work performed for Contractor by a Subcontractor or Supplier shall be pursuant to an appropriate contractual agreement that specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract Documents for the benefit of Owner and Engineer.

N. Owner may furnish to any Subcontractor or Supplier, to the extent practicable, information about amounts paid to Contractor on account of Work performed for Contractor by the particular Subcontractor or Supplier.

O. Nothing in the Contract Documents:

1. shall create for the benefit of any such Subcontractor, Supplier, or other individual or entity any contractual relationship between Owner or Engineer and any such Subcontractor, Supplier, or other individual or entity; nor

2. shall create any obligation on the part of Owner or Engineer to pay or to see to the payment of any money due any such Subcontractor, Supplier, or other individual or entity except as may otherwise be required by Laws and Regulations.

7.07 *Patent Fees and Royalties*

A. Contractor shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is

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the subject of patent rights or copyrights held by others. If a particular invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if, to the actual knowledge of Owner or Engineer, its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights shall be disclosed by Owner in the Contract Documents.

B. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, and its officers, directors, members, partners, employees, agents, consultants, and subcontractors from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device specified in the Contract Documents, but not identified as being subject to payment of any license fee or royalty to others required by patent rights or copyrights.

C. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

7.08 *Permits*

A. Unless otherwise provided in the Contract Documents, Contractor shall obtain and pay for all construction permits and licenses. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of the submission of Contractor's Bid (or when Contractor became bound under a negotiated contract). Owner shall pay all charges of utility owners for connections for providing permanent service to the Work

7.09 *Taxes*

A. Contractor shall pay all sales, consumer, use, and other similar taxes required to be paid by Contractor in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

7.10 *Laws and Regulations*

A. Contractor shall give all notices required by and shall comply with all Laws and Regulations applicable to the performance of the Work. Except where otherwise expressly required by applicable Laws and Regulations, neither Owner nor Engineer shall be responsible for monitoring Contractor's compliance with any Laws or Regulations.

B. If Contractor performs any Work or takes any other action knowing or having reason to know that it is contrary to Laws or Regulations, Contractor shall bear all resulting costs and losses, and shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work or other action. It shall not be Contractor's responsibility to make certain that the Work described in the Contract Documents is in accordance with Laws and Regulations, but this shall not relieve Contractor of Contractor's obligations under Paragraph 3.03.

C. Owner or Contractor may give notice to the other party of any changes after the submission of Contractor's Bid (or after the date when Contractor became bound under a negotiated contract) in Laws or Regulations having an effect on the cost or time of performance of the Work, including but not limited to changes in Laws or Regulations having an effect on procuring permits and on sales, use, value-added, consumption, and

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other similar taxes. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times resulting from such changes, then within 30 days of such notice Contractor may submit a Change Proposal, or Owner may initiate a Claim.

7.11 *Record Documents*

A. Contractor shall maintain in a safe place at the Site one printed record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, written interpretations and clarifications, and approved Shop Drawings. Contractor shall keep such record documents in good order and annotate them to show changes made during construction. These record documents, together with all approved Samples, will be available to Engineer for reference. Upon completion of the Work, Contractor shall deliver these record documents to Engineer.

7.12 *Safety and Protection*

A. Contractor shall be solely responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the Work. Such responsibility does not relieve Subcontractors of their responsibility for the safety of persons or property in the performance of their work, nor for compliance with applicable safety Laws and Regulations. Contractor shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury, or loss to:

1. all persons on the Site or who may be affected by the Work;

2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and

3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, other work in progress, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

B. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection. Contractor shall notify Owner; the owners of adjacent property, Underground Facilities, and other utilities; and other contractors and utility owners performing work at or adjacent to the Site, when prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property or work in progress.

C. Contractor shall comply with the applicable requirements of Owner's safety programs, if any. The Supplementary Conditions identify any Owner's safety programs that are applicable to the Work.

D. Contractor shall inform Owner and Engineer of the specific requirements of Contractor's safety program with which Owner's and Engineer's employees and representatives must comply while at the Site.

E. All damage, injury, or loss to any property referred to in Paragraph 7.12.A.2 or 7.12.A.3 caused, directly or indirectly, in whole or in part, by Contractor, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by Contractor at its expense (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of Owner or Engineer or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of Contractor or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them).

F. Contractor's duties and responsibilities for safety and protection shall continue until such time as all the Work is completed and Engineer has issued a notice to Owner and Contractor in accordance with Paragraph 15.06.B that the Work is acceptable (except as otherwise expressly provided in connection with Substantial Completion).

G. Contractor's duties and responsibilities for safety and protection shall resume whenever Contractor or any Subcontractor or Supplier returns to the Site to fulfill warranty or correction obligations, or to conduct other tasks arising from the Contract Documents.

7.13 *Safety Representative*

A. Contractor shall designate a qualified and experienced safety representative at the Site whose duties and responsibilities shall be the

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prevention of accidents and the maintaining and supervising of safety precautions and programs.

7.14 *Hazard Communication Programs*

A. Contractor shall be responsible for coordinating any exchange of material safety data sheets or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

7.15 *Emergencies*

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, Contractor is obligated to act to prevent threatened damage, injury, or loss. Contractor shall give Engineer prompt written notice if Contractor believes that any significant changes in the Work or variations from the Contract Documents have been caused thereby or are required as a result thereof. If Engineer determines that a change in the Contract Documents is required because of the action taken by Contractor in response to such an emergency, a Work Change Directive or Change Order will be issued.

7.16 *Shop Drawings, Samples, and Other Submittals*

A. Shop Drawing and Sample Submittal Requirements:

1. Before submitting a Shop Drawing or Sample, Contractor shall have:

a. reviewed and coordinated the Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;

b. determined and verified all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;

c. determined and verified the suitability of all materials and equipment offered with respect to the indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and

d. determined and verified all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto.

2. Each submittal shall bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review of that submittal, and that Contractor approves the submittal.

3. With each submittal, Contractor shall give Engineer specific written notice of any variations that the Shop Drawing or Sample may have from the requirements of the Contract Documents. This notice shall be set forth in a written communication separate from the Shop Drawings or Sample submittal; and, in addition, in the case of Shop Drawings by a specific notation made on each Shop Drawing submitted to Engineer for review and approval of each such variation.

B. *Submittal Procedures for Shop Drawings and Samples*: Contractor shall submit Shop Drawings and Samples to Engineer for review and approval in accordance with the accepted Schedule of Submittals. Each submittal will be identified as Engineer may require.

1. Shop Drawings:

a. Contractor shall submit the number of copies required in the Specifications.

b. Data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide and to enable Engineer to review the information for the limited purposes required by Paragraph 7.16.D.

2. Samples:

a. Contractor shall submit the number of Samples required in the Specifications.

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b. Contractor shall clearly identify each Sample as to material, Supplier, pertinent data such as catalog numbers, the use for which intended and other data as Engineer may require to enable Engineer to review the submittal for the limited purposes required by Paragraph 7.16.D.

3. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals, any related Work performed prior to Engineer's review and approval of the pertinent submittal will be at the sole expense and responsibility of Contractor.

C. *Other Submittals*: Contractor shall submit other submittals to Engineer in accordance with the accepted Schedule of Submittals, and pursuant to the applicable terms of the Specifications.

D. Engineer's Review:

1. Engineer will provide timely review of Shop Drawings and Samples in accordance with the Schedule of Submittals acceptable to Engineer. Engineer's review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

2. Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction or to safety precautions or programs incident thereto.

3. Engineer's review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

4. Engineer's review and approval of a Shop Drawing or Sample shall not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of Paragraph 7.16.A.3 and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample. Engineer will document any such approved variation from the requirements of the Contract Documents in a Field Order.

5. Engineer's review and approval of a Shop Drawing or Sample shall not relieve Contractor from responsibility for complying with the requirements of Paragraph 7.16.A and B.

6. Engineer's review and approval of a Shop Drawing or Sample, or of a variation from the requirements of the Contract Documents, shall not, under any circumstances, change the Contract Times or Contract Price, unless such changes are included in a Change Order.

7. Neither Engineer's receipt, review, acceptance or approval of a Shop Drawing, Sample, or other submittal shall result in such item becoming a Contract Document.

8. Contractor shall perform the Work in compliance with the requirements and commitments set forth in approved Shop Drawings and Samples, subject to the provisions of Paragraph 7.16.D.4.

E. Resubmittal Procedures:

1. Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous submittals.

2. Contractor shall furnish required submittals with sufficient information and accuracy to obtain required approval of an item with no more than three submittals. Engineer will record Engineer's time for reviewing a fourth or subsequent submittal of a Shop Drawings, sample, or other item requiring approval, and Contractor shall be responsible for Engineer's charges to Owner for such time. Owner may impose a set-off against payments due to Contractor to secure reimbursement for such charges.

3. If Contractor requests a change of a previously approved submittal item, Contractor shall be responsible for

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Engineer's charges to Owner for its review time, and Owner may impose a set-off against payments due to Contractor to secure reimbursement for such charges, unless the need for such change is beyond the control of Contractor.

7.17 *Contractor's General Warranty and Guarantee*

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and will not be defective. Engineer and its officers, directors, members, partners, employees, agents, consultants, and subcontractors shall be entitled to rely on Contractor's warranty and guarantee.

B. Contractor's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, modification, or improper maintenance or operation by persons other than Contractor, Subcontractors, Suppliers, or any other individual or entity for whom Contractor is responsible; or

2. normal wear and tear under normal usage.

C. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents or a release of Contractor's obligation to perform the Work in accordance with the Contract Documents:

1. observations by Engineer;

2. recommendation by Engineer or payment by Owner of any progress or final payment;

3. the issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;

4. use or occupancy of the Work or any part thereof by Owner;

5. any review and approval of a Shop Drawing or Sample submittal;

6. the issuance of a notice of acceptability by Engineer;

7. any inspection, test, or approval by others; or

8. any correction of defective Work by Owner.

D. If the Contract requires the Contractor to accept the assignment of a contract entered into by Owner, then the specific warranties, guarantees, and correction obligations contained in the assigned contract shall govern with respect to Contractor's performance obligations to Owner for the Work described in the assigned contract.

7.18 *Indemnification*

A. To the fullest extent permitted by Laws and Regulations, and in addition to any other obligations of Contractor under the Contract or otherwise, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the performance of the Work, provided that any such claim, cost, loss, or damage is attributable to bodily injury, sickness, disease, or death, or to injury to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom but only to the extent caused by any negligent act or omission of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work or anyone for whose acts any of them may be liable.

B. In any and all claims against Owner or Engineer or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors by any employee (or the survivor or personal representative of such employee) of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, the indemnification obligation under Paragraph 7.18.A shall not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

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C. The indemnification obligations of Contractor under Paragraph 7.18.A shall not extend to the liability of Engineer and Engineer's officers, directors, members, partners, employees, agents, consultants and subcontractors arising out of:

1. the preparation or approval of, or the failure to prepare or approve maps, Drawings, opinions, reports, surveys, Change Orders, designs, or Specifications; or

2. giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

7.19 *Delegation of Professional Design Services*

A. Contractor will not be required to provide professional design services unless such services are specifically required by the Contract Documents for a portion of the Work or unless such services are required to carry out Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. Contractor shall not be required to provide professional services in violation of applicable Laws and Regulations.

B. If professional design services or certifications by a design professional related to systems, materials, or equipment are specifically required of Contractor by the Contract Documents, Owner and Engineer will specify all performance and design criteria that such services must satisfy. Contractor shall cause such services or certifications to be provided by a properly licensed professional, whose signature and seal shall appear on all drawings, calculations, specifications, certifications, and other submittals prepared by such professional. Shop Drawings and other submittals related to the Work designed or certified by such professional, if prepared by others, shall bear such professional's written approval when submitted to Engineer.

C. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, or approvals performed by such design professionals, provided Owner and Engineer have specified to Contractor all performance and design criteria that such services must satisfy.

D. Pursuant to this paragraph, Engineer's review and approval of design calculations and design drawings will be only for the limited purpose of checking for conformance with performance and design criteria given and the design concept expressed in the Contract Documents. Engineer's review and approval of Shop Drawings and other submittals (except design calculations and design drawings) will be only for the purpose stated in Paragraph 7.16.D.1.

E. Contractor shall not be responsible for the adequacy of the performance or design criteria specified by Owner or Engineer.

ARTICLE 8 – OTHER WORK AT THE SITE

8.01 *Other Work*

A. In addition to and apart from the Work under the Contract Documents, the Owner may perform other work at or adjacent to the Site. Such other work may be performed by Owner's employees, or through contracts between the Owner and third parties. Owner may also arrange to have third-party utility owners perform work on their utilities and facilities at or adjacent to the Site.

B. If Owner performs other work at or adjacent to the Site with Owner's employees, or through contracts for such other work, then Owner shall give Contractor written notice thereof prior to starting any such other work. If Owner has advance information regarding the start of any utility work at or adjacent to the Site, Owner shall provide such information to Contractor.

C. Contractor shall afford each other contractor that performs such other work, each utility owner performing other work, and Owner, if Owner is performing other work with Owner's employees, proper and safe access to the Site, and provide a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work. Contractor shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. Contractor shall not endanger any work of others by cutting, excavating, or otherwise altering such work; provided, however, that Contractor may cut or alter others' work with the written consent of Engineer and the others whose work will be affected.

D. If the proper execution or results of any part of Contractor's Work depends upon work

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performed by others under this Article 8, Contractor shall inspect such other work and promptly report to Engineer in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of Contractor's Work. Contractor's failure to so report will constitute an acceptance of such other work as fit and proper for integration with Contractor's Work except for latent defects and deficiencies in such other work.

8.02 *Coordination*

A. If Owner intends to contract with others for the performance of other work at or adjacent to the Site, to perform other work at or adjacent to the Site with Owner's employees, or to arrange to have utility owners perform work at or adjacent to the Site, the following will be set forth in the Supplementary Conditions or provided to Contractor prior to the start of any such other work:

1. the identity of the individual or entity that will have authority and responsibility for coordination of the activities among the various contractors;

2. an itemization of the specific matters to be covered by such authority and responsibility; and

3. the extent of such authority and responsibilities.

B. Unless otherwise provided in the Supplementary Conditions, Owner shall have sole authority and responsibility for such coordination.

8.03 *Legal Relationships*

A. If, in the course of performing other work at or adjacent to the Site for Owner, the Owner's employees, any other contractor working for Owner, or any utility owner causes damage to the Work or to the property of Contractor or its Subcontractors, or delays, disrupts, interferes with, or increases the scope or cost of the performance of the Work, through actions or inaction, then Contractor shall be entitled to an equitable adjustment in the Contract Price or the Contract Times, or both. Contractor must submit any Change Proposal seeking an equitable adjustment in the Contract Price or the Contract Times under this paragraph within 30 days of the damaging, delaying, disrupting, or interfering event. The entitlement to, and extent of, any such equitable adjustment shall take into account information (if any) regarding such other work that was provided to Contractor in the Contract Documents prior to the submittal of the Bid or the final negotiation of the terms of the Contract. When applicable, any such equitable adjustment in Contract Price shall be conditioned on Contractor assigning to Owner all Contractor's rights against such other contractor or utility owner with respect to the damage, delay, disruption, or interference that is the subject of the adjustment. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times.

B. Contractor shall take reasonable and customary measures to avoid damaging, delaying, disrupting, or interfering with the work of Owner, any other contractor, or any utility owner performing other work at or adjacent to the Site. If Contractor fails to take such measures and as a result damages, delays, disrupts, or interferes with the work of any such other contractor or utility owner, then Owner may impose a set-off against payments due to Contractor, and assign to such other contractor or utility owner the Owner's contractual rights against Contractor with respect to the breach of the obligations set forth in this paragraph.

C. When Owner is performing other work at or adjacent to the Site with Owner's employees, Contractor shall be liable to Owner for damage to such other work, and for the reasonable direct delay, disruption, and interference costs incurred by Owner as a result of Contractor's failure to take reasonable and customary measures with respect to Owner's other work. In response to such damage, delay, disruption, or interference, Owner may impose a set-off against payments due to Contractor.

D. If Contractor damages, delays, disrupts, or interferes with the work of any other contractor, or any utility owner performing other work at or adjacent to the Site, through Contractor's failure to take reasonable and customary measures to avoid such impacts, or if any claim arising out of Contractor's actions, inactions, or negligence in performance of the Work at or adjacent to the Site is made by any such other contractor or utility owner against Contractor, Owner, or Engineer, then Contractor shall (1) promptly attempt to settle the claim as to all parties through negotiations with such other contractor or utility owner, or otherwise

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resolve the claim by arbitration or other dispute resolution proceeding or at law, and (2) indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against any such claims, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such damage, delay, disruption, or interference.

ARTICLE 9 – OWNER'S RESPONSIBILITIES

9.01 *Communications to Contractor*

A. Except as otherwise provided in these General Conditions, Owner shall issue all communications to Contractor through Engineer.

9.02 *Replacement of Engineer*

A. Owner may at its discretion appoint an engineer to replace Engineer, provided Contractor makes no reasonable objection to the replacement engineer. The replacement engineer's status under the Contract Documents shall be that of the former Engineer.

9.03 *Furnish Data*

A. Owner shall promptly furnish the data required of Owner under the Contract Documents.

9.04 *Pay When Due*

A. Owner shall make payments to Contractor when they are due as provided in the Agreement.

9.05 *Lands and Easements; Reports, Tests, and Drawings*

A. Owner's duties with respect to providing lands and easements are set forth in Paragraph 5.01.

B. Owner's duties with respect to providing engineering surveys to establish reference points are set forth in Paragraph 4.03.

C. Article 5 refers to Owner's identifying and making available to Contractor copies of reports of explorations and tests of conditions at the Site, and drawings of physical conditions relating to existing surface or subsurface structures at the Site.

9.06 *Insurance*

A. Owner's responsibilities, if any, with respect to purchasing and maintaining liability and property insurance are set forth in Article 6.

9.07 *Change Orders*

A. Owner's responsibilities with respect to Change Orders are set forth in Article 11.

9.08 *Inspections, Tests, and Approvals*

A. Owner's responsibility with respect to certain inspections, tests, and approvals is set forth in Paragraph 14.02.B.

9.09 *Limitations on Owner's Responsibilities*

A. The Owner shall not supervise, direct, or have control or authority over, nor be responsible for, Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Owner will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

9.10 *Undisclosed Hazardous Environmental Condition*

A. Owner's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in Paragraph 5.06.

9.11 *Evidence of Financial Arrangements*

A. Upon request of Contractor, Owner shall furnish Contractor reasonable evidence that financial arrangements have been made to satisfy Owner's obligations under the Contract Documents (including obligations under proposed changes in the Work).

9.12 *Safety Programs*

A. While at the Site, Owner's employees and representatives shall comply with the specific applicable requirements of Contractor's safety programs of which Owner has been informed.

B. Owner shall furnish copies of any applicable Owner safety programs to Contractor.

ARTICLE 10 – ENGINEER'S STATUS DURING CONSTRUCTION

10.01 *Owner's Representative*

A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's

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representative during construction are set forth in the Contract.

10.02 *Visits to Site*

A. Engineer will make visits to the Site at intervals appropriate to the various stages of construction as Engineer deems necessary in order to observe as an experienced and qualified design professional the progress that has been made and the quality of the various aspects of Contractor's executed Work. Based on information obtained during such visits and observations, Engineer, for the benefit of Owner, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. Engineer will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. Engineer's efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, Engineer will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defective Work.

B. Engineer's visits and observations are subject to all the limitations on Engineer's authority and responsibility set forth in Paragraph 10.08. Particularly, but without limitation, during or as a result of Engineer's visits or observations of Contractor's Work, Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work.

10.03 *Project Representative*

A. If Owner and Engineer have agreed that Engineer will furnish a Resident Project Representative to represent Engineer at the Site and assist Engineer in observing the progress and quality of the Work, then the authority and responsibilities of any such Resident Project Representative will be as provided in the Supplementary Conditions, and limitations on the responsibilities thereof will be as provided in Paragraph 10.08. If Owner designates another representative or agent to represent Owner at the Site who is not Engineer's consultant, agent, or employee, the responsibilities and authority and limitations thereon of such other individual or entity will be as provided in the Supplementary Conditions.

10.04 *Rejecting Defective Work*

A. Engineer has the authority to reject Work in accordance with Article 14.

10.05 *Shop Drawings, Change Orders and Payments*

A. Engineer's authority, and limitations thereof, as to Shop Drawings and Samples, are set forth in Paragraph 7.16.

B. Engineer's authority, and limitations thereof, as to design calculations and design drawings submitted in response to a delegation of professional design services, if any, are set forth in Paragraph 7.19.

C. Engineer's authority as to Change Orders is set forth in Article 11.

D. Engineer's authority as to Applications for Payment is set forth in Article 15.

10.06 *Determinations for Unit Price Work*

A. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor as set forth in Paragraph 13.03.

10.07 *Decisions on Requirements of Contract Documents and Acceptability of Work*

A. Engineer will render decisions regarding the requirements of the Contract Documents, and judge the acceptability of the Work, pursuant to the specific procedures set forth herein for initial interpretations, Change Proposals, and acceptance of the Work. In rendering such decisions and judgments, Engineer will not show partiality to Owner or Contractor, and will not be liable to Owner, Contractor, or others in connection with any proceedings, interpretations, decisions, or judgments conducted or rendered in good faith.

10.08 *Limitations on Engineer's Authority and Responsibilities*

A. Neither Engineer's authority or responsibility under this Article 10 or under any other provision of the Contract, nor any decision made by Engineer in good faith either to exercise or not exercise such authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by Engineer, shall create, impose, or give rise to any duty in contract, tort, or otherwise owed by Engineer to Contractor, any Subcontractor, any Supplier, any other individual or entity, or

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to any surety for or employee or agent of any of them.

B. Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Engineer will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

C. Engineer will not be responsible for the acts or omissions of Contractor or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. Engineer's review of the final Application for Payment and accompanying documentation and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by Paragraph 15.06.A will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals, that the results certified indicate compliance with the Contract Documents.

E. The limitations upon authority and responsibility set forth in this Paragraph 10.08 shall also apply to the Resident Project Representative, if any.

10.09 *Compliance with Safety Program*

A. While at the Site, Engineer's employees and representatives will comply with the specific applicable requirements of Owner's and Contractor's safety programs (if any) of which Engineer has been informed.

ARTICLE 11 – AMENDING THE CONTRACT DOCUMENTS; CHANGES IN THE WORK

11.01 *Amending and Supplementing Contract Documents*

A. The Contract Documents may be amended or supplemented by a Change Order, a Work Change Directive, or a Field Order.

1. Change Orders:

a. If an amendment or supplement to the Contract Documents includes a change in the Contract Price or the Contract Times, such amendment or supplement must be set forth in a Change Order. A Change Order also may be used to establish amendments and supplements of the Contract Documents that do not affect the Contract Price or Contract Times.

b. Owner and Contractor may amend those terms and conditions of the Contract Documents that do not involve (1) the performance or acceptability of the Work, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, without the recommendation of the Engineer. Such an amendment shall be set forth in a Change Order.

2. *Work Change Directives*: A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the modification ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order, following negotiations by the parties as to the Work Change Directive's effect, if any, on the Contract Price and Contract Times; or, if negotiations are unsuccessful, by a determination under the terms of the Contract Documents governing adjustments, expressly including Paragraph 11.04 regarding change of Contract Price. Contractor must submit any Change Proposal seeking an adjustment of the Contract Price or the Contract Times, or both, no later than 30 days after the completion of the Work set out in the Work Change Directive. Owner must submit any Claim seeking an adjustment of the Contract Price or the Contract Times, or both, no later than 60 days after issuance of the Work Change Directive.

3. *Field Orders*: Engineer may authorize minor changes in the Work if the changes do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. Such changes will be accomplished by a Field Order and will be binding on Owner and also on

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Contractor, which shall perform the Work involved promptly. If Contractor believes that a Field Order justifies an adjustment in the Contract Price or Contract Times, or both, then before proceeding with the Work at issue, Contractor shall submit a Change Proposal as provided herein.

11.02 *Owner-Authorized Changes in the Work*

A. Without invalidating the Contract and without notice to any surety, Owner may, at any time or from time to time, order additions, deletions, or revisions in the Work. Such changes shall be supported by Engineer's recommendation, to the extent the change involves the design (as set forth in the Drawings, Specifications, or otherwise), or other engineering or technical matters. Such changes may be accomplished by a Change Order, if Owner and Contractor have agreed as to the effect, if any, of the changes on Contract Times or Contract Price; or by a Work Change Directive. Upon receipt of any such document, Contractor shall promptly proceed with the Work involved; or, in the case of a deletion in the Work, promptly cease construction activities with respect to such deleted Work. Added or revised Work shall be performed under the applicable conditions of the Contract Documents. Nothing in this paragraph shall obligate Contractor to undertake work that Contractor reasonably concludes cannot be performed in a manner consistent with Contractor's safety obligations under the Contract Documents or Laws and Regulations.

11.03 *Unauthorized Changes in the Work*

A. Contractor shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents, as amended, modified, or supplemented, except in the case of an emergency as provided in Paragraph 7.15 or in the case of uncovering Work as provided in Paragraph 14.05.

11.04 *Change of Contract Price*

A. The Contract Price may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Price shall comply with the provisions of Paragraph 11.06. Any Claim for an adjustment of Contract Price shall comply with the provisions of Article 12.

B. An adjustment in the Contract Price will be determined as follows:

1. where the Work involved is covered by unit prices contained in the Contract Documents, then by application of such unit prices to the quantities of the items involved (subject to the provisions of Paragraph 13.03); or

2. where the Work involved is not covered by unit prices contained in the Contract Documents, then by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with Paragraph 11.04.C.2); or

3. where the Work involved is not covered by unit prices contained in the Contract Documents and the parties do not reach mutual agreement to a lump sum, then on the basis of the Cost of the Work (determined as provided in Paragraph 13.01) plus a Contractor's fee for overhead and profit (determined as provided in Paragraph 11.04.C).

C. *Contractor's Fee*: When applicable, the Contractor's fee for overhead and profit shall be determined as follows:

1. a mutually acceptable fixed fee; or

2. if a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:

   a. for costs incurred under Paragraphs 13.01.B.1 and 13.01.B.2, the Contractor's fee shall be 15 percent;

   b. for costs incurred under Paragraph 13.01.B.3, the Contractor's fee shall be five percent;

   c. where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of Paragraphs 11.01.C.2.a and 11.01.C.2.b is that the Contractor's fee shall be based on: (1) a fee of 15 percent of the costs incurred under Paragraphs 13.01.A.1 and 13.01.A.2 by the Subcontractor that actually performs the Work, at whatever tier, and (2) with respect to Contractor itself and to any Subcontractors of a tier higher than

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that of the Subcontractor that actually performs the Work, a fee of five percent of the amount (fee plus underlying costs incurred) attributable to the next lower tier Subcontractor; provided, however, that for any such subcontracted work the maximum total fee to be paid by Owner shall be no greater than 27 percent of the costs incurred by the Subcontractor that actually performs the work;

d. no fee shall be payable on the basis of costs itemized under Paragraphs 13.01.B.4, 13.01.B.5, and 13.01.C;

e. the amount of credit to be allowed by Contractor to Owner for any change which results in a net decrease in cost will be the amount of the actual net decrease in cost plus a deduction in Contractor's fee by an amount equal to five percent of such net decrease; and

f. when both additions and credits are involved in any one change, the adjustment in Contractor's fee shall be computed on the basis of the net change in accordance with Paragraphs 11.04.C.2.a through 11.04.C.2.e, inclusive.

11.05 *Change of Contract Times*

A. The Contract Times may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Times shall comply with the provisions of Paragraph 11.06. Any Claim for an adjustment in the Contract Times shall comply with the provisions of Article 12.

B. An adjustment of the Contract Times shall be subject to the limitations set forth in Paragraph 4.05, concerning delays in Contractor's progress.

11.06 *Change Proposals*

A. Contractor shall submit a Change Proposal to Engineer to request an adjustment in the Contract Times or Contract Price; appeal an initial decision by Engineer concerning the requirements of the Contract Documents or relating to the acceptability of the Work under the Contract Documents; contest a set-off against payment due; or seek other relief under the Contract. The Change Proposal shall specify any proposed change in Contract Times or Contract Price, or both, or other proposed relief, and explain the reason for the proposed change, with citations to any governing or applicable provisions of the Contract Documents.

1. *Procedures*: Contractor shall submit each Change Proposal to Engineer promptly (but in no event later than 30 days) after the start of the event giving rise thereto, or after such initial decision. The Contractor shall submit supporting data, including the proposed change in Contract Price or Contract Time (if any), to the Engineer and Owner within 15 days after the submittal of the Change Proposal. The supporting data shall be accompanied by a written statement that the supporting data are accurate and complete, and that any requested time or price adjustment is the entire adjustment to which Contractor believes it is entitled as a result of said event. Engineer will advise Owner regarding the Change Proposal, and consider any comments or response from Owner regarding the Change Proposal.

2. *Engineer's Action*: Engineer will review each Change Proposal and, within 30 days after receipt of the Contractor's supporting data, either deny the Change Proposal in whole, approve it in whole, or deny it in part and approve it in part. Such actions shall be in writing, with a copy provided to Owner and Contractor. If Engineer does not take action on the Change Proposal within 30 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of Engineer's inaction the Change Proposal is deemed denied, thereby commencing the time for appeal of the denial under Article 12.

3. *Binding Decision*: Engineer's decision will be final and binding upon Owner and Contractor, unless Owner or Contractor appeals the decision by filing a Claim under Article 12.

B. *Resolution of Certain Change Proposals*: If the Change Proposal does not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters, then Engineer will notify the parties that the Engineer is unable to resolve the Change Proposal. For purposes of further resolution of such a Change Proposal, such notice shall be deemed a denial, and

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Contractor may choose to seek resolution under the terms of Article 12.

11.07 *Execution of Change Orders*

A. Owner and Contractor shall execute appropriate Change Orders covering:

1. changes in the Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive;

2. changes in Contract Price resulting from an Owner set-off, unless Contractor has duly contested such set-off;

3. changes in the Work which are: (a) ordered by Owner pursuant to Paragraph 11.02, (b) required because of Owner's acceptance of defective Work under Paragraph 14.04 or Owner's correction of defective Work under Paragraph 14.07, or (c) agreed to by the parties, subject to the need for Engineer's recommendation if the change in the Work involves the design (as set forth in the Drawings, Specifications, or otherwise), or other engineering or technical matters; and

4. changes in the Contract Price or Contract Times, or other changes, which embody the substance of any final and binding results under Paragraph 11.06, or Article 12.

B. If Owner or Contractor refuses to execute a Change Order that is required to be executed under the terms of this Paragraph 11.07, it shall be deemed to be of full force and effect, as if fully executed.

11.08 *Notification to Surety*

A. If the provisions of any bond require notice to be given to a surety of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times), the giving of any such notice will be Contractor's responsibility. The amount of each applicable bond will be adjusted to reflect the effect of any such change.

ARTICLE 12 – CLAIMS

12.01 *Claims*

A. *Claims Process*: The following disputes between Owner and Contractor shall be submitted to the Claims process set forth in this Article:

1. Appeals by Owner or Contractor of Engineer's decisions regarding Change Proposals;

2. Owner demands for adjustments in the Contract Price or Contract Times, or other relief under the Contract Documents; and

3. Disputes that Engineer has been unable to address because they do not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters.

B. *Submittal of Claim*: The party submitting a Claim shall deliver it directly to the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto; in the case of appeals regarding Change Proposals within 30 days of the decision under appeal. The party submitting the Claim shall also furnish a copy to the Engineer, for its information only. The responsibility to substantiate a Claim shall rest with the party making the Claim. In the case of a Claim by Contractor seeking an increase in the Contract Times or Contract Price, or both, Contractor shall certify that the Claim is made in good faith, that the supporting data are accurate and complete, and that to the best of Contractor's knowledge and belief the amount of time or money requested accurately reflects the full amount to which Contractor is entitled.

C. *Review and Resolution*: The party receiving a Claim shall review it thoroughly, giving full consideration to its merits. The two parties shall seek to resolve the Claim through the exchange of information and direct negotiations. The parties may extend the time for resolving the Claim by mutual agreement. All actions taken on a Claim shall be stated in writing and submitted to the other party, with a copy to Engineer.

D. Mediation:

1. At any time after initiation of a Claim, Owner and Contractor may mutually

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agree to mediation of the underlying dispute. The agreement to mediate shall stay the Claim submittal and response process.

2. If Owner and Contractor agree to mediation, then after 60 days from such agreement, either Owner or Contractor may unilaterally terminate the mediation process, and the Claim submittal and decision process shall resume as of the date of the termination. If the mediation proceeds but is unsuccessful in resolving the dispute, the Claim submittal and decision process shall resume as of the date of the conclusion of the mediation, as determined by the mediator.

3. Owner and Contractor shall each pay one-half of the mediator's fees and costs.

E. *Partial Approval*: If the party receiving a Claim approves the Claim in part and denies it in part, such action shall be final and binding unless within 30 days of such action the other party invokes the procedure set forth in Article 17 for final resolution of disputes.

F. *Denial of Claim*: If efforts to resolve a Claim are not successful, the party receiving the Claim may deny it by giving written notice of denial to the other party. If the receiving party does not take action on the Claim within 90 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of the inaction, the Claim is deemed denied, thereby commencing the time for appeal of the denial. A denial of the Claim shall be final and binding unless within 30 days of the denial the other party invokes the procedure set forth in Article 17 for the final resolution of disputes.

G. *Final and Binding Results*: If the parties reach a mutual agreement regarding a Claim, whether through approval of the Claim, direct negotiations, mediation, or otherwise; or if a Claim is approved in part and denied in part, or denied in full, and such actions become final and binding; then the results of the agreement or action on the Claim shall be incorporated in a Change Order to the extent they affect the Contract, including the Work, the Contract Times, or the Contract Price.

ARTICLE 13 – COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

13.01 *Cost of the Work*

A. *Purposes for Determination of Cost of the Work*: The term Cost of the Work means the sum of all costs necessary for the proper performance of the Work at issue, as further defined below. The provisions of this Paragraph 13.01 are used for two distinct purposes:

1. To determine Cost of the Work when Cost of the Work is a component of the Contract Price, under cost-plus-fee, time-and-materials, or other cost-based terms; or

2. To determine the value of a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price. When the value of any such adjustment is determined on the basis of Cost of the Work, Contractor is entitled only to those additional or incremental costs required because of the change in the Work or because of the event giving rise to the adjustment.

B. *Costs Included*: Except as otherwise may be agreed to in writing by Owner, costs included in the Cost of the Work shall be in amounts no higher than those prevailing in the locality of the Project, shall not include any of the costs itemized in Paragraph 13.01.C, and shall include only the following items:

1. Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by Owner and Contractor. Such employees shall include, without limitation, superintendents, foremen, and other personnel employed full time on the Work. Payroll costs for employees not employed full time on the Work shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits, which shall include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, bonuses, sick leave, and vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours,

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on Saturday, Sunday, or legal holidays, shall be included in the above to the extent authorized by Owner.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts shall accrue to Contractor unless Owner deposits funds with Contractor with which to make payments, in which case the cash discounts shall accrue to Owner. All trade discounts, rebates, and refunds and returns from sale of surplus materials and equipment shall accrue to Owner, and Contractor shall make provisions so that they may be obtained.

3. Payments made by Contractor to Subcontractors for Work performed by Subcontractors. If required by Owner, Contractor shall obtain competitive bids from subcontractors acceptable to Owner and Contractor and shall deliver such bids to Owner, who will then determine, with the advice of Engineer, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee shall be determined in the same manner as Contractor's Cost of the Work and fee as provided in this Paragraph 13.01.

4. Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed for services specifically related to the Work.

5. Supplemental costs including the following:

    a. The proportion of necessary transportation, travel, and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work.

    b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost, less market value, of such items used but not consumed which remain the property of Contractor.

    c. Rentals of all construction equipment and machinery, and the parts thereof, whether rented from Contractor or others in accordance with rental agreements approved by Owner with the advice of Engineer, and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs shall be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts shall cease when the use thereof is no longer necessary for the Work.

    d. Sales, consumer, use, and other similar taxes related to the Work, and for which Contractor is liable, as imposed by Laws and Regulations.

    e. Deposits lost for causes other than negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

    f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by Contractor in connection with the performance of the Work (except losses and damages within the deductible amounts of property insurance established in accordance with Paragraph 6.05), provided such losses and damages have resulted from causes other than the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses shall include settlements made with the written consent and approval of Owner. No such losses, damages, and expenses shall be included in the Cost of the Work for the

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purpose of determining Contractor's fee.

g. The cost of utilities, fuel, and sanitary facilities at the Site.

h. Minor expenses such as communication service at the Site, express and courier services, and similar petty cash items in connection with the Work.

i. The costs of premiums for all bonds and insurance that Contractor is required by the Contract Documents to purchase and maintain.

C. *Costs Excluded*: The term Cost of the Work shall not include any of the following items:

1. Payroll costs and other compensation of Contractor's officers, executives, principals (of partnerships and sole proprietorships), general managers, safety managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by Contractor, whether at the Site or in Contractor's principal or branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in Paragraph 13.01.B.1 or specifically covered by Paragraph 13.01.B.4. The payroll costs and other compensation excluded here are to be considered administrative costs covered by the Contractor's fee.

2. Expenses of Contractor's principal and branch offices other than Contractor's office at the Site.

3. Any part of Contractor's capital expenses, including interest on Contractor's capital employed for the Work and charges against Contractor for delinquent payments.

4. Costs due to the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.

5. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in Paragraph 13.01.B.

D. *Contractor's Fee*: When the Work as a whole is performed on the basis of cost-plus, Contractor's fee shall be determined as set forth in the Agreement. When the value of any Work covered by a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price is determined on the basis of Cost of the Work, Contractor's fee shall be determined as set forth in Paragraph 11.04.C.

E. *Documentation*: Whenever the Cost of the Work for any purpose is to be determined pursuant to this Article 13, Contractor will establish and maintain records thereof in accordance with generally accepted accounting practices and submit in a form acceptable to Engineer an itemized cost breakdown together with supporting data.

13.02 *Allowances*

A. It is understood that Contractor has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be performed for such sums and by such persons or entities as may be acceptable to Owner and Engineer.

B. *Cash Allowances*: Contractor agrees that:

1. the cash allowances include the cost to Contractor (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and

2. Contractor's costs for unloading and handling on the Site, labor, installation, overhead, profit, and other expenses contemplated for the cash allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment on account of any of the foregoing will be valid.

C. *Contingency Allowance*: Contractor agrees that a contingency allowance, if any, is for the sole use of Owner to cover unanticipated costs.

D. Prior to final payment, an appropriate Change Order will be issued as recommended by Engineer to reflect actual amounts due Contractor on account of Work covered by

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allowances, and the Contract Price shall be correspondingly adjusted.

13.03 *Unit Price Work*

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement.

B. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Payments to Contractor for Unit Price Work will be based on actual quantities.

C. Each unit price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

D. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor. Engineer will review with Contractor the Engineer's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). Engineer's written decision thereon will be final and binding (except as modified by Engineer to reflect changed factual conditions or more accurate data) upon Owner and Contractor, subject to the provisions of the following paragraph.

E. Within 30 days of Engineer's written decision under the preceding paragraph, Contractor may submit a Change Proposal, or Owner may file a Claim, seeking an adjustment in the Contract Price if:

1. the quantity of any item of Unit Price Work performed by Contractor differs materially and significantly from the estimated quantity of such item indicated in the Agreement;

2. there is no corresponding adjustment with respect to any other item of Work; and

3. Contractor believes that it is entitled to an increase in Contract Price as a result of having incurred additional expense or Owner believes that Owner is entitled to a decrease in Contract Price, and the parties are unable to agree as to the amount of any such increase or decrease.

ARTICLE 14 – TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK

14.01 *Access to Work*

A. Owner, Engineer, their consultants and other representatives and personnel of Owner, independent testing laboratories, and authorities having jurisdiction will have access to the Site and the Work at reasonable times for their observation, inspection, and testing. Contractor shall provide them proper and safe conditions for such access and advise them of Contractor's safety procedures and programs so that they may comply therewith as applicable.

14.02 *Tests, Inspections, and Approvals*

A. Contractor shall give Engineer timely notice of readiness of the Work (or specific parts thereof) for all required inspections and tests, and shall cooperate with inspection and testing personnel to facilitate required inspections and tests.

B. Owner shall retain and pay for the services of an independent inspector, testing laboratory, or other qualified individual or entity to perform all inspections and tests expressly required by the Contract Documents to be furnished and paid for by Owner, except that costs incurred in connection with tests or inspections of covered Work shall be governed by the provisions of Paragraph 14.05.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, Contractor shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish Engineer the required certificates of inspection or approval.

D. Contractor shall be responsible for arranging, obtaining, and paying for all inspections and tests required:

1. by the Contract Documents, unless the Contract Documents expressly allocate responsibility for a specific inspection or test to Owner;

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2. to attain Owner's and Engineer's acceptance of materials or equipment to be incorporated in the Work;

3. by manufacturers of equipment furnished under the Contract Documents;

4. for testing, adjusting, and balancing of mechanical, electrical, and other equipment to be incorporated into the Work; and

5. for acceptance of materials, mix designs, or equipment submitted for approval prior to Contractor's purchase thereof for incorporation in the Work.

Such inspections and tests shall be performed by independent inspectors, testing laboratories, or other qualified individuals or entities acceptable to Owner and Engineer.

E. If the Contract Documents require the Work (or part thereof) to be approved by Owner, Engineer, or another designated individual or entity, then Contractor shall assume full responsibility for arranging and obtaining such approvals.

F. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by Contractor without written concurrence of Engineer, Contractor shall, if requested by Engineer, uncover such Work for observation. Such uncovering shall be at Contractor's expense unless Contractor had given Engineer timely notice of Contractor's intention to cover the same and Engineer had not acted with reasonable promptness in response to such notice.

14.03 *Defective Work*

A. *Contractor's Obligation*: It is Contractor's obligation to assure that the Work is not defective.

B. *Engineer's Authority*: Engineer has the authority to determine whether Work is defective, and to reject defective Work.

C. *Notice of Defects*: Prompt notice of all defective Work of which Owner or Engineer has actual knowledge will be given to Contractor.

D. *Correction, or Removal and Replacement*: Promptly after receipt of written notice of defective Work, Contractor shall correct all such defective Work, whether or not fabricated, installed, or completed, or, if Engineer has rejected the defective Work, remove it from the Project and replace it with Work that is not defective.

E. *Preservation of Warranties*: When correcting defective Work, Contractor shall take no action that would void or otherwise impair Owner's special warranty and guarantee, if any, on said Work.

F. *Costs and Damages*: In addition to its correction, removal, and replacement obligations with respect to defective Work, Contractor shall pay all claims, costs, losses, and damages arising out of or relating to defective Work, including but not limited to the cost of the inspection, testing, correction, removal, replacement, or reconstruction of such defective Work, fines levied against Owner by governmental authorities because the Work is defective, and the costs of repair or replacement of work of others resulting from defective Work. Prior to final payment, if Owner and Contractor are unable to agree as to the measure of such claims, costs, losses, and damages resulting from defective Work, then Owner may impose a reasonable set-off against payments due under Article 15.

14.04 *Acceptance of Defective Work*

A. If, instead of requiring correction or removal and replacement of defective Work, Owner prefers to accept it, Owner may do so (subject, if such acceptance occurs prior to final payment, to Engineer's confirmation that such acceptance is in general accord with the design intent and applicable engineering principles, and will not endanger public safety). Contractor shall pay all claims, costs, losses, and damages attributable to Owner's evaluation of and determination to accept such defective Work (such costs to be approved by Engineer as to reasonableness), and for the diminished value of the Work to the extent not otherwise paid by Contractor. If any such acceptance occurs prior to final payment, the necessary revisions in the Contract Documents with respect to the Work shall be incorporated in a Change Order. If the parties are unable to agree as to the decrease in the Contract Price, reflecting the diminished value of Work so accepted, then Owner may impose a reasonable set-off against payments due under Article 15. If the acceptance of defective Work occurs after final payment, Contractor shall pay an appropriate amount to Owner.

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14.05 *Uncovering Work*

A. Engineer has the authority to require special inspection or testing of the Work, whether or not the Work is fabricated, installed, or completed.

B. If any Work is covered contrary to the written request of Engineer, then Contractor shall, if requested by Engineer, uncover such Work for Engineer's observation, and then replace the covering, all at Contractor's expense.

C. If Engineer considers it necessary or advisable that covered Work be observed by Engineer or inspected or tested by others, then Contractor, at Engineer's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as Engineer may require, that portion of the Work in question, and provide all necessary labor, material, and equipment.

1. If it is found that the uncovered Work is defective, Contractor shall be responsible for all claims, costs, losses, and damages arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and pending Contractor's full discharge of this responsibility the Owner shall be entitled to impose a reasonable set-off against payments due under Article 15.

2. If the uncovered Work is not found to be defective, Contractor shall be allowed an increase in the Contract Price or an extension of the Contract Times, or both, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, then Contractor may submit a Change Proposal within 30 days of the determination that the Work is not defective.

14.06 *Owner May Stop the Work*

A. If the Work is defective, or Contractor fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, then Owner may order Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of Owner to stop the Work shall not give rise to any duty on the part of Owner to exercise this right for the benefit of Contractor, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

14.07 *Owner May Correct Defective Work*

A. If Contractor fails within a reasonable time after written notice from Engineer to correct defective Work, or to remove and replace rejected Work as required by Engineer, or if Contractor fails to perform the Work in accordance with the Contract Documents, or if Contractor fails to comply with any other provision of the Contract Documents, then Owner may, after seven days written notice to Contractor, correct or remedy any such deficiency.

B. In exercising the rights and remedies under this Paragraph 14.07, Owner shall proceed expeditiously. In connection with such corrective or remedial action, Owner may exclude Contractor from all or part of the Site, take possession of all or part of the Work and suspend Contractor's services related thereto, and incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere. Contractor shall allow Owner, Owner's representatives, agents and employees, Owner's other contractors, and Engineer and Engineer's consultants access to the Site to enable Owner to exercise the rights and remedies under this paragraph.

C. All claims, costs, losses, and damages incurred or sustained by Owner in exercising the rights and remedies under this Paragraph 14.07 will be charged against Contractor as set-offs against payments due under Article 15. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of Contractor's defective Work.

D. Contractor shall not be allowed an extension of the Contract Times because of any delay in the performance of the Work attributable to the exercise by Owner of Owner's rights and remedies under this Paragraph 14.07.

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ARTICLE 15 – PAYMENTS TO CONTRACTOR; SET-OFFS; COMPLETION; CORRECTION PERIOD

15.01 *Progress Payments*

A. *Basis for Progress Payments*: The Schedule of Values established as provided in Article 2 will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to Engineer. Progress payments on account of Unit Price Work will be based on the number of units completed during the pay period, as determined under the provisions of Paragraph 13.03. Progress payments for cost-based Work will be based on Cost of the Work completed by Contractor during the pay period.

B. Applications for Payments:

1. At least 20 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment shall also be accompanied by a bill of sale, invoice, or other documentation warranting that Owner has received the materials and equipment free and clear of all Liens, and evidence that the materials and equipment are covered by appropriate property insurance, a warehouse bond, or other arrangements to protect Owner's interest therein, all of which must be satisfactory to Owner.

2. Beginning with the second Application for Payment, each Application shall include an affidavit of Contractor stating that all previous progress payments received on account of the Work have been applied on account to discharge Contractor's legitimate obligations associated with prior Applications for Payment.

3. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

C. Review of Applications:

1. Engineer will, within 10 days after receipt of each Application for Payment, including each resubmittal, either indicate in writing a recommendation of payment and present the Application to Owner, or return the Application to Contractor indicating in writing Engineer's reasons for refusing to recommend payment. In the latter case, Contractor may make the necessary corrections and resubmit the Application.

2. Engineer's recommendation of any payment requested in an Application for Payment will constitute a representation by Engineer to Owner, based on Engineer's observations of the executed Work as an experienced and qualified design professional, and on Engineer's review of the Application for Payment and the accompanying data and schedules, that to the best of Engineer's knowledge, information and belief:

a. the Work has progressed to the point indicated;

b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, the results of any subsequent tests called for in the Contract Documents, a final determination of quantities and classifications for Unit Price Work under Paragraph 13.03, and any other qualifications stated in the recommendation); and

c. the conditions precedent to Contractor's being entitled to such payment appear to have been fulfilled in so far as it is Engineer's responsibility to observe the Work.

3. By recommending any such payment Engineer will not thereby be deemed to have represented that:

a. inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every

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aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to Engineer in the Contract; or

b. there may not be other matters or issues between the parties that might entitle Contractor to be paid additionally by Owner or entitle Owner to withhold payment to Contractor.

4. Neither Engineer's review of Contractor's Work for the purposes of recommending payments nor Engineer's recommendation of any payment, including final payment, will impose responsibility on Engineer:

a. to supervise, direct, or control the Work, or

b. for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or

c. for Contractor's failure to comply with Laws and Regulations applicable to Contractor's performance of the Work, or

d. to make any examination to ascertain how or for what purposes Contractor has used the money paid on account of the Contract Price, or

e. to determine that title to any of the Work, materials, or equipment has passed to Owner free and clear of any Liens.

5. Engineer may refuse to recommend the whole or any part of any payment if, in Engineer's opinion, it would be incorrect to make the representations to Owner stated in Paragraph 15.01.C.2.

6. Engineer will recommend reductions in payment (set-offs) necessary in Engineer's opinion to protect Owner from loss because:

a. the Work is defective, requiring correction or replacement;

b. the Contract Price has been reduced by Change Orders;

c. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;

d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible; or

e. Engineer has actual knowledge of the occurrence of any of the events that would constitute a default by Contractor and therefore justify termination for cause under the Contract Documents.

D. Payment Becomes Due:

1. Ten days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended (subject to any Owner set-offs) will become due, and when due will be paid by Owner to Contractor.

E. Reductions in Payment by Owner:

1. In addition to any reductions in payment (set-offs) recommended by Engineer, Owner is entitled to impose a set-off against payment based on any of the following:

a. claims have been made against Owner on account of Contractor's conduct in the performance or furnishing of the Work, or Owner has incurred costs, losses, or damages on account of Contractor's conduct in the performance or furnishing of the Work, including but not limited to claims, costs, losses, or damages from workplace injuries, adjacent property damage, non-compliance with Laws and Regulations, and patent infringement;

b. Contractor has failed to take reasonable and customary measures to avoid damage, delay, disruption, and interference with other work at or adjacent to the Site;

c. Contractor has failed to provide and maintain required bonds or insurance;

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d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible;

e. Owner has incurred extra charges or engineering costs related to submittal reviews, evaluations of proposed substitutes, tests and inspections, or return visits to manufacturing or assembly facilities;

f. the Work is defective, requiring correction or replacement;

g. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;

h. the Contract Price has been reduced by Change Orders;

i. an event that would constitute a default by Contractor and therefore justify a termination for cause has occurred;

j. liquidated damages have accrued as a result of Contractor's failure to achieve Milestones, Substantial Completion, or final completion of the Work;

k. Liens have been filed in connection with the Work, except where Contractor has delivered a specific bond satisfactory to Owner to secure the satisfaction and discharge of such Liens;

l. there are other items entitling Owner to a set off against the amount recommended.

2. If Owner imposes any set-off against payment, whether based on its own knowledge or on the written recommendations of Engineer, Owner will give Contractor immediate written notice (with a copy to Engineer) stating the reasons for such action and the specific amount of the reduction, and promptly pay Contractor any amount remaining after deduction of the amount so withheld. Owner shall promptly pay Contractor the amount so withheld, or any adjustment thereto agreed to by Owner and Contractor, if Contractor remedies the reasons for such action. The reduction imposed shall be binding on Contractor unless it duly submits a Change Proposal contesting the reduction.

3. Upon a subsequent determination that Owner's refusal of payment was not justified, the amount wrongfully withheld shall be treated as an amount due as determined by Paragraph 15.01.C.1 and subject to interest as provided in the Agreement.

15.02 *Contractor's Warranty of Title*

A. Contractor warrants and guarantees that title to all Work, materials, and equipment furnished under the Contract will pass to Owner free and clear of (1) all Liens and other title defects, and (2) all patent, licensing, copyright, or royalty obligations, no later than seven days after the time of payment by Owner.

15.03 *Substantial Completion*

A. When Contractor considers the entire Work ready for its intended use Contractor shall notify Owner and Engineer in writing that the entire Work is substantially complete and request that Engineer issue a certificate of Substantial Completion. Contractor shall at the same time submit to Owner and Engineer an initial draft of punch list items to be completed or corrected before final payment.

B. Promptly after Contractor's notification, Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

C. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a preliminary certificate of Substantial Completion which shall fix the date of Substantial Completion. Engineer shall attach to the certificate a punch list of items to be completed or corrected before final payment. Owner shall have seven days after receipt of the preliminary certificate during which to make written objection to Engineer as to any provisions of the certificate or attached punch list. If, after considering the objections to the provisions of the preliminary certificate, Engineer concludes that the Work is not substantially complete, Engineer will, within 14 days after submission of the preliminary certificate to Owner, notify Contractor in

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writing that the Work is not substantially complete, stating the reasons therefor. If Owner does not object to the provisions of the certificate, or if despite consideration of Owner's objections Engineer concludes that the Work is substantially complete, then Engineer will, within said 14 days, execute and deliver to Owner and Contractor a final certificate of Substantial Completion (with a revised punch list of items to be completed or corrected) reflecting such changes from the preliminary certificate as Engineer believes justified after consideration of any objections from Owner.

D. At the time of receipt of the preliminary certificate of Substantial Completion, Owner and Contractor will confer regarding Owner's use or occupancy of the Work following Substantial Completion, review the builder's risk insurance policy with respect to the end of the builder's risk coverage, and confirm the transition to coverage of the Work under a permanent property insurance policy held by Owner. Unless Owner and Contractor agree otherwise in writing, Owner shall bear responsibility for security, operation, protection of the Work, property insurance, maintenance, heat, and utilities upon Owner's use or occupancy of the Work.

E. After Substantial Completion the Contractor shall promptly begin work on the punch list of items to be completed or corrected prior to final payment. In appropriate cases Contractor may submit monthly Applications for Payment for completed punch list items, following the progress payment procedures set forth above.

F. Owner shall have the right to exclude Contractor from the Site after the date of Substantial Completion subject to allowing Contractor reasonable access to remove its property and complete or correct items on the punch list.

15.04 *Partial Use or Occupancy*

A. Prior to Substantial Completion of all the Work, Owner may use or occupy any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which Owner, Engineer, and Contractor agree constitutes a separately functioning and usable part of the Work that can be used by Owner for its intended purpose without significant interference with Contractor's performance of the remainder of the Work, subject to the following conditions:

1. At any time Owner may request in writing that Contractor permit Owner to use or occupy any such part of the Work that Owner believes to be substantially complete. If and when Contractor agrees that such part of the Work is substantially complete, Contractor, Owner, and Engineer will follow the procedures of Paragraph 15.03.A through E for that part of the Work.

2. At any time Contractor may notify Owner and Engineer in writing that Contractor considers any such part of the Work substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.

3. Within a reasonable time after either such request, Owner, Contractor, and Engineer shall make an inspection of that part of the Work to determine its status of completion. If Engineer does not consider that part of the Work to be substantially complete, Engineer will notify Owner and Contractor in writing giving the reasons therefor. If Engineer considers that part of the Work to be substantially complete, the provisions of Paragraph 15.03 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

4. No use or occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of Paragraph 6.05 regarding builder's risk or other property insurance.

15.05 *Final Inspection*

A. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work, or agreed portion thereof, is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

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15.06 *Final Payment*

A. Application for Payment:

1. After Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, bonds, certificates or other evidence of insurance, certificates of inspection, annotated record documents (as provided in Paragraph 7.11), and other documents, Contractor may make application for final payment.

2. The final Application for Payment shall be accompanied (except as previously delivered) by:

a. all documentation called for in the Contract Documents;

b. consent of the surety, if any, to final payment;

c. satisfactory evidence that all title issues have been resolved such that title to all Work, materials, and equipment has passed to Owner free and clear of any Liens or other title defects, or will so pass upon final payment.

d. a list of all disputes that Contractor believes are unsettled; and

e. complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of the Work, and of Liens filed in connection with the Work.

3. In lieu of the releases or waivers of Liens specified in Paragraph 15.06.A.2 and as approved by Owner, Contractor may furnish receipts or releases in full and an affidavit of Contractor that: (a) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (b) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which Owner might in any way be responsible, or which might in any way result in liens or other burdens on Owner's property, have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, Contractor may furnish a bond or other collateral satisfactory to Owner to indemnify Owner against any Lien, or Owner at its option may issue joint checks payable to Contractor and specified Subcontractors and Suppliers.

B. Engineer's Review of Application and Acceptance:

1. If, on the basis of Engineer's observation of the Work during construction and final inspection, and Engineer's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, Engineer is satisfied that the Work has been completed and Contractor's other obligations under the Contract have been fulfilled, Engineer will, within ten days after receipt of the final Application for Payment, indicate in writing Engineer's recommendation of final payment and present the Application for Payment to Owner for payment. Such recommendation shall account for any set-offs against payment that are necessary in Engineer's opinion to protect Owner from loss for the reasons stated above with respect to progress payments. At the same time Engineer will also give written notice to Owner and Contractor that the Work is acceptable, subject to the provisions of Paragraph 15.07. Otherwise, Engineer will return the Application for Payment to Contractor, indicating in writing the reasons for refusing to recommend final payment, in which case Contractor shall make the necessary corrections and resubmit the Application for Payment.

C. *Completion of Work*: The Work is complete (subject to surviving obligations) when it is ready for final payment as established by the Engineer's written recommendation of final payment.

D. *Payment Becomes Due*: Thirty days after the presentation to Owner of the final Application for Payment and accompanying documentation, the amount recommended by Engineer (less any further sum Owner is entitled to set off against Engineer's recommendation, including but not limited to set-offs for liquidated damages and set-offs allowed under the provisions above with respect to progress payments) will become due and shall be paid by Owner to Contractor.

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15.07 *Waiver of Claims*

A. The making of final payment will not constitute a waiver by Owner of claims or rights against Contractor. Owner expressly reserves claims and rights arising from unsettled Liens, from defective Work appearing after final inspection pursuant to Paragraph 15.05, from Contractor's failure to comply with the Contract Documents or the terms of any special guarantees specified therein, from outstanding Claims by Owner, or from Contractor's continuing obligations under the Contract Documents.

B. The acceptance of final payment by Contractor will constitute a waiver by Contractor of all claims and rights against Owner other than those pending matters that have been duly submitted or appealed under the provisions of Article 17.

15.08 *Correction Period*

A. If within one year after the date of Substantial Completion (or such longer period of time as may be prescribed by the terms of any applicable special guarantee required by the Contract Documents, or by any specific provision of the Contract Documents), any Work is found to be defective, or if the repair of any damages to the Site, adjacent areas that Contractor has arranged to use through construction easements or otherwise, and other adjacent areas used by Contractor as permitted by Laws and Regulations, is found to be defective, then Contractor shall promptly, without cost to Owner and in accordance with Owner's written instructions:

1. correct the defective repairs to the Site or such other adjacent areas;
2. correct such defective Work;
3. if the defective Work has been rejected by Owner, remove it from the Project and replace it with Work that is not defective, and
4. satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others, or to other land or areas resulting therefrom.

B. If Contractor does not promptly comply with the terms of Owner's written instructions, or in an emergency where delay would cause serious risk of loss or damage, Owner may have the defective Work corrected or repaired or may have the rejected Work removed and replaced. Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others).

C. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications.

D. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this paragraph, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

E. Contractor's obligations under this paragraph are in addition to all other obligations and warranties. The provisions of this paragraph shall not be construed as a substitute for, or a waiver of, the provisions of any applicable statute of limitation or repose.

ARTICLE 16 – SUSPENSION OF WORK AND TERMINATION

16.01 *Owner May Suspend Work*

A. At any time and without cause, Owner may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by written notice to Contractor and Engineer. Such notice will fix the date on which Work will be resumed. Contractor shall resume the Work on the date so fixed. Contractor shall be entitled to an adjustment in the Contract Price or an extension of the Contract Times, or both, directly attributable to any such suspension. Any Change Proposal seeking such adjustments shall be submitted no later than 30 days after the date fixed for resumption of Work.

16.02 *Owner May Terminate for Cause*

A. The occurrence of any one or more of the following events will constitute a default by Contractor and justify termination for cause:

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1. Contractor's persistent failure to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment or failure to adhere to the Progress Schedule);

2. Failure of Contractor to perform or otherwise to comply with a material term of the Contract Documents;

3. Contractor's disregard of Laws or Regulations of any public body having jurisdiction; or

4. Contractor's repeated disregard of the authority of Owner or Engineer.

B. If one or more of the events identified in Paragraph 16.02.A occurs, then after giving Contractor (and any surety) ten days written notice that Owner is considering a declaration that Contractor is in default and termination of the contract, Owner may proceed to:

1. declare Contractor to be in default, and give Contractor (and any surety) notice that the Contract is terminated; and

2. enforce the rights available to Owner under any applicable performance bond.

C. Subject to the terms and operation of any applicable performance bond, if Owner has terminated the Contract for cause, Owner may exclude Contractor from the Site, take possession of the Work, incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere, and complete the Work as Owner may deem expedient.

D. Owner may not proceed with termination of the Contract under Paragraph 16.02.B if Contractor within seven days of receipt of notice of intent to terminate begins to correct its failure to perform and proceeds diligently to cure such failure.

E. If Owner proceeds as provided in Paragraph 16.02.B, Contractor shall not be entitled to receive any further payment until the Work is completed. If the unpaid balance of the Contract Price exceeds the cost to complete the Work, including all related claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals) sustained by Owner, such excess will be paid to Contractor. If the cost to complete the Work including such related claims, costs, losses, and damages exceeds such unpaid balance, Contractor shall pay the difference to Owner. Such claims, costs, losses, and damages incurred by Owner will be reviewed by Engineer as to their reasonableness and, when so approved by Engineer, incorporated in a Change Order. When exercising any rights or remedies under this paragraph, Owner shall not be required to obtain the lowest price for the Work performed.

F. Where Contractor's services have been so terminated by Owner, the termination will not affect any rights or remedies of Owner against Contractor then existing or which may thereafter accrue, or any rights or remedies of Owner against Contractor or any surety under any payment bond or performance bond. Any retention or payment of money due Contractor by Owner will not release Contractor from liability.

G. If and to the extent that Contractor has provided a performance bond under the provisions of Paragraph 6.01.A, the provisions of that bond shall govern over any inconsistent provisions of Paragraphs 16.02.B and 16.02.D.

16.03 *Owner May Terminate For Convenience*

A. Upon seven days written notice to Contractor and Engineer, Owner may, without cause and without prejudice to any other right or remedy of Owner, terminate the Contract. In such case, Contractor shall be paid for (without duplication of any items):

1. completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;

2. expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses; and

3. other reasonable expenses directly attributable to termination, including costs incurred to prepare a termination for convenience cost proposal.

B. Contractor shall not be paid on account of loss of anticipated overhead, profits, or revenue, or

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other economic loss arising out of or resulting from such termination.

16.04 *Contractor May Stop Work or Terminate*

A. If, through no act or fault of Contractor, (1) the Work is suspended for more than 90 consecutive days by Owner or under an order of court or other public authority, or (2) Engineer fails to act on any Application for Payment within 30 days after it is submitted, or (3) Owner fails for 30 days to pay Contractor any sum finally determined to be due, then Contractor may, upon seven days written notice to Owner and Engineer, and provided Owner or Engineer do not remedy such suspension or failure within that time, terminate the contract and recover from Owner payment on the same terms as provided in Paragraph 16.03.

B. In lieu of terminating the Contract and without prejudice to any other right or remedy, if Engineer has failed to act on an Application for Payment within 30 days after it is submitted, or Owner has failed for 30 days to pay Contractor any sum finally determined to be due, Contractor may, seven days after written notice to Owner and Engineer, stop the Work until payment is made of all such amounts due Contractor, including interest thereon. The provisions of this paragraph are not intended to preclude Contractor from submitting a Change Proposal for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to Contractor's stopping the Work as permitted by this paragraph.

ARTICLE 17 – FINAL RESOLUTION OF DISPUTES

17.01 *Methods and Procedures*

A. *Disputes Subject to Final Resolution*: The following disputed matters are subject to final resolution under the provisions of this Article:

1. A timely appeal of an approval in part and denial in part of a Claim, or of a denial in full; and

2. Disputes between Owner and Contractor concerning the Work or obligations under the Contract Documents, and arising after final payment has been made.

B. *Final Resolution of Disputes*: For any dispute subject to resolution under this Article, Owner or Contractor may:

1. elect in writing to invoke the dispute resolution process provided for in the Supplementary Conditions; or

2. agree with the other party to submit the dispute to another dispute resolution process; or

3. if no dispute resolution process is provided for in the Supplementary Conditions or mutually agreed to, give written notice to the other party of the intent to submit the dispute to a court of competent jurisdiction.

ARTICLE 18 – MISCELLANEOUS

18.01 *Giving Notice*

A. Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if:

1. delivered in person, by a commercial courier service or otherwise, to the individual or to a member of the firm or to an officer of the corporation for which it is intended; or

2. delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the sender of the notice.

18.02 *Computation of Times*

A. When any period of time is referred to in the Contract by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

18.03 *Cumulative Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract. The provisions of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty,

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obligation, right, and remedy to which they apply.

18.04 *Limitation of Damages*

A. With respect to any and all Change Proposals, Claims, disputes subject to final resolution, and other matters at issue, neither Owner nor Engineer, nor any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, shall be liable to Contractor for any claims, costs, losses, or damages sustained by Contractor on or in connection with any other project or anticipated project.

18.05 *No Waiver*

A. A party's non-enforcement of any provision shall not constitute a waiver of that provision, nor shall it affect the enforceability of that provision or of the remainder of this Contract.

18.06 *Survival of Obligations*

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract, as well as all continuing obligations indicated in the Contract, will survive final payment, completion, and acceptance of the Work or termination or completion of the Contract or termination of the services of Contractor.

18.07 *Controlling Law*

A. This Contract is to be governed by the law of the state in which the Project is located.

18.08 *Headings*

A. Article and paragraph headings are inserted for convenience only and do not constitute parts of these General Conditions.

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SECTION 00800
SUPPLEMENTARY CONDITIONS

These Supplementary Conditions amend or supplement the Standard General Conditions of the Construction Contract as indicated below. All provisions that are not so amended or supplemented remain in full force and effect.

The terms used in these Supplementary Conditions have the meanings stated in the General Conditions. Additional terms used in these Supplementary Conditions have the meanings stated below, which are applicable to both the singular and plural thereof. The address system used in these Supplementary Conditions is the same as the address system used in the General Conditions, with the prefix "SC" added thereto.

SC-1.01.A.8 – Insert at the end of the definition in Paragraph 1.01.A.8, the following:

However, notwithstanding anything herein, a Change Proposal shall not result in a Change Order unless recommended by the Engineer and accepted by the Owner.

SC-1.01.A – Add the following paragraphs after Paragraph 1.01.A.48:

49. Construction Manager: Person or entity designated by the Owner to provide construction management services for the Project with duties, responsibilities, and limitations of the Engineer, unless stipulated otherwise.

50. Equipment (Construction): All machinery and equipment, together with the necessary supplies for upkeep and maintenance, including tools and apparatus necessary for the proper construction and acceptable completion of the Work contemplated. (Installation) All material or articles used in equipping a facility or apparatus required to fulfill a functional design.

51. Specialist— The term Specialist refers to a person, partnership, firm, or corporation of established reputation (or if newly organized, whose personnel have previously established a reputation in the same field), which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the Contract Documents, or otherwise performing Work required by the Contract Documents. Where the Specifications require the installation by a Specialist, that term shall also be deemed to mean either the manufacturer of the item, a person, partnership, firm, or corporation licensed by the manufacturer, or a person, partnership, firm, or corporation who will perform the Work under the manufacturer's direct supervision.

52. Utility: Any public or private fixed works for transporting fluids, gases, electricity, signals, or communications.

53. Deferred Submittals: Contractor-designed portions of the Work. Deferred Submittals are listed in the Contract Documents and as requested by authorities having jurisdiction.

SC-1.02.F – Add the following paragraph after Paragraph 1.02.F:

Where a discrepancy, error or ambiguity is discovered or occurs between words and phrases, Contractor shall request clarification in accordance with Article 3.

SC-2.01.A - *Delivery of Bonds*

Delete 2.01.A in its entirety and replace it with the following:

A. Bonds:
   1. If Contractor chooses not to sign the Contract electronically, Contractor will deliver the bonds Contractor is required to furnish with the executed counterparts of the Contract to Owner.
   2. If the Contract will be signed electronically, Contractor will deliver the bonds Contractor is required to furnish within 5 days of Owner's Notice of Award of the Contract to Contractor.

SC-2.01.B -*Evidence of Insurance*

Delete 2.01.B in its entirety and replace it with the following:

B. Evidence of Contractor's Insurance:
   1. If the Contract is not being signed electronically, when Contractor delivers the executed counterparts of the Contract to Owner, Contractor will also deliver to Owner, with copies to each additional insured identified by name in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which either of them or any additional insured may reasonably request) for the insurance coverages that Contractor is required to purchase and maintain in accordance with Article 6.
   2. If the Contract is being signed electronically, when Contractor delivers the bonds to Owner, Contractor will deliver to Owner, with copies to each additional insured identified by name in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which either of them or any additional insured may reasonably request) for the insurance coverages that Contractor is required to purchase and maintain in accordance with Article 6.

SC-2.02.A - *Copies of Documents*

Delete Paragraph 2.02.A in its entirety and replace it with the following:

If the Contract is not being signed electronically, Owner will furnish Contractor up to three copies of the Contract Documents. Additional copies will be furnished upon request at the cost of reproduction.

If the Contract is being signed electronically, Owner will provide Contractor with an electronic copy of the complete Contract Document or access to a complete copy, and Contractor will be responsible for making its own copies.

SC-2.02.B – Add the following paragraphs after Paragraph 2.02.B:

C. An electronic portable document format (PDF) of the Contract will be available on Owner-provided digital project management software for reference and use by Contractor, as referenced in Paragraph 2.06.A.

1. Contractor shall utilize PDF writing software for recording processes, markup and editing Project forms. Handwritten forms are not acceptable, except for signatures and legible filling of substitution request forms.

SC-2.06.B – Delete Paragraph 2.06.B in its entirety and replace it with the following paragraphs:

B. Owner will provide web-based Project management software (PM Software) Procore Technologies, Inc. for documents and communication in accordance with Section 01320 "Web Based Construction Management."

1. Contractor shall utilize PM Software for document collection, record and control, and electronic transmittals. Contractor is responsible for maintaining documents issued by Owner and Engineer.

SC – 3.01.B – Add the following at the end of Paragraph 3.01.B:

All labor, services, materials, or equipment that reasonably may be inferred from the Contract Documents or from prevailing custom or trade usage as being required to produce the indicated results will be provided whether or not specifically called for, at no additional cost to Owner. Contractor shall be responsible for verifying the accuracy of all grades, elevations, dimensions, locations and field measurements. In all cases of the interconnection of its Work with existing or other work, Contractor shall verify at the Site all dimensions relating to such existing or other work. Any errors due to Contractor's failure to verify all such grades, elevations, dimensions, locations, or field measurements shall be promptly corrected by Contractor without any additional costs to the Owner or extensions of Contract Times.

SC -3.03.A.3 – Add the following paragraph after Paragraph 3.03.A.3:

a. However, Contractor shall be liable to Owner where such conditions reasonably could have been discovered or revealed as a result of review, examination, investigation, exploration, coordination or study of the Contract Documents conducted by the Contractor prior to Contractor's proceeding with Work, as required by Paragraphs 3.03.A.1, 3.03.A.2 and 7.06.J.

SC-3.03.B.1 – Add the following paragraph after Paragraph 3.03.B.1.b:

c. In resolving inconsistencies among two or more components of the Contract Documents, precedence shall be given in the following order:

1. Agreement
2. Addenda
3. Contractor's Bid (Bid Form)
4. Supplementary Conditions
5. Standard General Conditions of the Construction Contract
6. Permits
7. Specifications – Division 01
8. Specifications – All remaining Divisions
9. Drawings and Standard Details
10. Bonds

Change Orders, Work Change Directives, Field Orders, Engineer's written interpretation and clarifications and Notice to Proceed, in precedence listed, will take precedence over all other Contract Document components referenced herein. The Drawings with the higher level of detail take precedence over less detailed Drawings.

SC-4.01.A – Delete the last sentence of Paragraph 4.01.A in its entirety.

SC-4.04.A –Add the following after subparagraph 4.04.A.2:

3. If Contractor falls behind the accepted Progress Schedule, Contractor shall submit for review no later than the time of submittal of the next request for partial payment, such supplementary schedule or schedules as may be necessary to demonstrate the manner in which the acceptable rate of progress will be regained, all without additional cost to Owner. Owner may set-off payment in accordance with Article 15 until updated progress schedule is submitted and approved.

SC-4.05.C.2 – Add the following at the end of Paragraph 4.05.C.2:

Such requests shall be accompanied with supporting documentation referenced to the NOAA INDEX weather in the Project vicinity.

SC- 4.05.G – Change "within 30 days" to "within 10 days"

SC-4.05 – Add the following paragraph after Paragraph 4.05.G:

H. Contractor shall proceed expeditiously with adequate forces and shall achieve the Contract Times. Contractor shall accelerate the Work as required to achieve Contract Times at no additional cost to the Owner. Accelerated Work shall include, but not be limited to, expedited delivery of materials and equipment, increasing the number of workers, working overtime, and working additional shifts.

I. In no event shall Owner or Engineer be liable to Contractor, any Subcontractor, any Supplier, or any other person or organization, or to any surety for or employee or agent of

any of them, for damages arising out of or resulting from (1) delays caused by or within the control of Contractor, Subcontractors, Suppliers, agents and representatives; or (2) delays beyond the control of Owner including but not limited to fires, floods, epidemics, abnormal weather conditions, or acts of God.

SC-5.01.B – Delete Paragraph 5.01.B in its entirety.

SC-5.02.D – Add the following paragraph after Paragraph 5.02.D:

1. Contractor to confirm with Engineer in writing, weight limitations of supporting structure prior to placement of materials and equipment, unless limitations are otherwise indicated on Drawings.

SC-5.03.A.1 – Add the following language after Paragraph 5.03.A.1:

a. Report dated April 29, 2024 prepared by Jacobs Engineering Group Inc**,** entitled Geotechnical Data Report consisting of 260 pages. The Technical Data contained in such report upon whose accuracy Contractor may rely on are those indicated in the definition of Technical Data in the General Conditions.

SC-5.03.A.2 – Add the following language after Paragraph 5.03.A.2:

a. Drawings dated 1991 prepared by HDR Engineering, Inc., entitled Durham Advanced Wastewater Treatment Plant Chemical Expansion consisting of 347 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

b. Drawings dated December 2002 prepared by HDR Engineering, Inc., entitled Durham Facility Phase 3 Expansion, Volume 4 of 5, Book A consisting of 96 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

c. Drawings dated December 2002 prepared by HDR Engineering, Inc., entitled Durham Facility Phase 3 Expansion, Volume 4 of 5, Book B consisting of 118 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

d. Drawings dated December 2002 prepared by HDR Engineering, Inc., entitled Durham Facility Phase 3 Expansion, Volume 5 of 5 consisting of 233 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

e. Drawings dated November 2008 prepared by MWH, entitled Durham Wastewater Treatment Facility, Phase 4 Expansion consisting of 428 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

f. Drawings dated June 2013 prepared by CH2MHill, entitled Durham Advanced Wastewater Treatment Facility Phase 5D2 Cogeneration and Brown Grease Receiving Facilities consisting of 239 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

g. Drawings dated July 2022 prepared by Brown and Caldwell, entitled Durham AWWTF FOG Tank Retrofit consisting of 63 sheets. All of the information in such drawings constitutes Technical Data on whose accuracy Contractor may rely.

C. Contractor may examine copies of reports and drawings identified in SC-5.03.A.1. and SC-5.03.A.2. that were not included with the Bidding Documents at Durham Treatment Plant Services (TPS) Building, 16060 SW 85th Ave, Tigard, Oregon 97224,, during regular business hours by appointment, or may request copies from Engineer.

SC-5.03.B – In the first sentence of 5.03.B, insert the word "reasonably" between the words "may" and "rely" and delete the second sentence (beginning with "Such" and ending with "Conditions") of Paragraph 5.03.B.

SC-5.06 - Delete Paragraph 5.06.A and Paragraph 5.06.B in their entirety and replace them with the following:

A. No reports or drawings related to Hazardous Environmental Conditions are known to Owner.

SC-6.01.A - Add the following language after Paragraph 6.01.A:

Provide the following additional bond(s):

1. Contractor's Public Works Bond:

a. Public works bond in the amount of $30,000 in accordance with the requirements of ORS 279C.836.

SC-6.03.A - Add the following paragraph after Paragraph 6.03.A.4:

5. The limits of liability for the insurance required by Paragraph 6.03.A shall provide coverage for not less than the following amounts or greater where required by Laws and Regulations:

A. Workers' Compensation and related coverages under Paragraph 6.03.A:

1. State: Minimum limit $1,000,000

2. United States Longshoreman and Harbor Workers' Compensation Act and Jones Act Coverage: if applicable.

3. Employer's Liability:

Bodily Injury, Each Accident: $ 1,000,000

Bodily Injury by Disease, Each Employee: $ 1,000,000

Bodily Injury/Disease Aggregate: $ 1,000,000

For work performed in monopolistic states, stop-gap liability coverage shall be endorsed to either the worker's compensation or commercial general liability policy with a minimum limit of: $ 1,000,000

4. Foreign Voluntary Worker Compensation: if applicable

SC-6.03.B - Add the following paragraph after Paragraph 6.03.B:

Contractor's Commercial General Liability under Paragraph 6.03.B, as either primary coverage or through a combination of primary and excess/umbrella liability:

a. General Aggregate

Contract Bid	Per Occurrence Limit
< $100,000	$ 1,000,000
$100,000 to $1,000,000	$ 2,000,000
> $1,000,000	$ 10,000,000

b. Products - Completed Operations Aggregate

Contract Bid	Per Occurrence Limit
< $100,000	$ 1,000,000
$100,000 to $1,000,000	$ 2,000,000
> $1,000,000	$ 10,000,000

c. Personal and Advertising Injury (per person/Organization) **$ 2,000,000**

d. Each Occurrence (Bodily Injury and Property Damage) **$ 2,000,000**

SC-6.03.D - Add the following paragraph after Paragraph 6.03.D:

1. Contractor's Automobile Liability

a. Bodily Injury:

Each Person **$ 1,000,000**

Each Accident **$ 1,000,000**

b. Property Damage:

Each Accident **$ 1,000,000**

c. Combined Single Limit of **$ 1,000,000**

SC-6.03.F - Add the following paragraph after Paragraph 6.03.F:

1. Pollution Liability:

a) Each Occurrence **$ 2,000,000**

b) General Aggregate **$ 2,000,000**

SC-6.03.G - Add the following paragraph after Paragraph 6.03.G:

1. Include the following parties or entities as additional insured:

a. **Clean Water Services**, 2550 S.W. Hillsboro Highway, Hillsboro, Oregon 97123**.**

b. **Jacobs Engineering Group Inc.**, 1100 NE Circle Blvd., Suite 300, Corvallis, OR 97330.

SC-6.03.H - Add the following paragraph after Paragraph 6.03.H:

1. Contractor's Professional Liability:

a) Each Claim **$ 1,000,000**

b) Annual Aggregate **$ 1,000,000**

SC-6.05.A.2 - Add the following paragraph after 6.05.A.2:

a. be maintained in effect until final payment is made unless otherwise agreed to in writing by Owner, Contractor, and Engineer with 30 days

written notice to each other loss payee to whom a certificate of insurance has been issued; and

b. Comply with the requirements of Paragraph 6.05.A.

SC-6.05.A - Add the following paragraph(s) after Paragraph 6.05.A.13:

14. Property insurance furnished under this Contract shall have deductibles no greater than $50,000 for direct physical loss in any one occurrence, including losses arising from flood. Earthquake deductible shall not exceed 10% of insured values.

15. Include for the benefit of Owner loss of profits and soft cost coverage including, without limitation, fixed expenses and debt service for a minimum of 12 months with a maximum deductible of 30 days, plus attorney's fees and engineering or other consultants' fees, if not otherwise covered;

16. Include, in addition to the Contract Price amount, the value of the following equipment and materials to be installed by the Contractor but furnished by the Owner or third parties:

    a. None.

17. Include by express endorsement coverage of damage to Contractor's equipment.

SC-6.06.B – Delete Paragraph 6.06.B in its entirety.

SC-6.06.C – Delete Paragraph 6.06.C in its entirety.

SC-7.01.B – Add the following language after the first sentence of Paragraph 7.01.B:

If a replacement is necessary, the replacement shall also be a competent resident superintendent and shall be subject to approval by Owner. The Contractor's superintendent shall be present at the Site at all times while Work is in progress and shall be available by phone for emergencies 24 hours per day, 7 days per week. If at anytime the superintendent leaves the Project Site while Work is in progress, Engineer shall be notified and provided with the name of the Contractor's representative having responsible charge.

SC-7.02.B - Add the following language at the end of Paragraph 7.02.B:

Contractor shall comply with ORS 279C.520.

1. Contractor and Subcontractor regular working hours consist of 7:00 a.m. and 5:00 p.m., Monday through Friday excluding holidays. If a change to these

standard hours is desired, a request must be placed with and approved by Owner and Engineer a minimum of five work days prior to the first day of altered hours.

2. Owner's legal holidays are **New Year's Day, Martin Luther King Jr. Day, Memorial Day, Juneteenth, Independence Day, Labor Day, Veteran's Day, Thanksgiving Day, and Christmas Day.**

SC-7.08 - Add the following paragraphs after Paragraph 7.08.A:

B. Owner will obtain and pay for the following construction permits and licenses:

1. Building permit.
2. Site work permit.
3. Mechanical permit.
4. Plumbing – site utilities permit.
5. Tree removal permit.

C. A copy of each permit is available at Durham TPS Building, 16060 SW 85th Ave, Tigard, Oregon 97224. Contractor shall examine the permits and conform to the requirements contained therein, including the purchase of additional bonds or insurance as specified therein, and such requirements are hereby made a part of these Contract Documents as fully and completely as though the same were set forth herein. Failure to examine the permit(s) will not relieve Contractor from compliance with the requirements stated therein. Within **30** days after the date of signing the Agreement, Contractor shall confer with an agent of the permitting agency so that insurance requirements and similar matters can be arranged prior to the time set for that portion of the Work.

D. Contractor will apply for, obtain and pay the cost for the Electrical permit.

E. Contractor shall obtain all permits and licenses for Deferred Submittals.
Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Owner shall pay for all permits and licenses for Deferred Submittals and governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of the submission of Contractor's Bid (or when Contractor became bound under a negotiated contract).

SC-7.10.B – Delete the final sentence of Paragraph 7.10.B.

SC-7.10 - Add the following paragraph after Paragraph 7.10.C:

D. Those Laws and Regulations for which Contractor may be responsible are included as required by law or for the convenience of the Contractor in the Standard Contract Clauses, Oregon Revised Statutes attached as Exhibit B to the Supplementary Conditions.

SC- 7.11 A. Delete Paragraph 7.11 A in its entirety, and replace it with the following:

A. Contractor shall maintain in a safe place at the Site one digital file for all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, written interpretations and clarifications, and approved Shop Drawings and as specified in Section 01330, Submittal Procedures. Contractor shall keep such record documents in good order and annotate them to show changes made during construction. These record documents, together with all approved Samples, will be available to Engineer for reference and for review. Upon completion of the Work, Engineer will review these record documents for conformance with revisions to Contract Documents. Contractor shall revise errors or discrepancies found by Engineer. Upon completion of corrections, Contractor shall deliver record documents to Engineer.

1. Recording of revisions on Drawings and Specifications shall be legible and in a digital file format, without markups by hand.

B. Contractor shall use electronic PM Software provided by Owner in Paragraph 2.06A for compiling, maintaining and archiving for each issuance, revision and record of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, written interpretations and clarifications, approved Shop Drawings and other documents used in the Work.

SC-7.12.C – Add the following language immediately after Paragraph 7.12.C

Contractors and Owners Safety Plan requirements are in Section 01329.

SC-7.16.B.1.a – Delete Paragraph 7.16.B.1.a in its entirety and replace it with the following the paragraph:

a. Contractor shall submit in electronic transmittal in the digital format required in the Specifications, unless other formats are requested by Engineer or specified otherwise.

SC-7.16.E.2 – Add the following paragraph after Paragraph 7.16.E.2.

a. Engineer’s reimbursement rate as set forth in Paragraph 10.01.A.1.

SC-7.17.A – Delete the second sentence of Paragraph 7.17.A.

SC-7.18.A – Delete Paragraph 7.18.A and replace it with the following:

To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify, hold harmless, reimburse and defend Owner and Engineer and the officers, directors, partners, members, employees, agents, consultants and subcontractors of each and any of them, and the successors in interest of the foregoing, from, for and against suits, actions, claims, damages, penalties, liabilities, losses and expenses (including but not limited to all fees and related costs, disbursements and expenses of engineers, architects, attorneys and expert witness’ fees) arising out of or resulting from the performance of the Work, but only to the extent caused by the negligence, breach of contract, breach of warranty (express or implied) or other improper conduct of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or

indirectly employed by any of them to perform any of the Work or anyone for whose acts any of them may be liable.

SC-7.18.B – Insert "To the fullest extent permitted by Laws and Regulations," at the start of Paragraph 7.18.B.

SC-7.19.B – Add the following sentence to the end of Paragraph 7.19.B:

The design professional shall be registered in the State of Oregon.

SC-9.02.A – In Paragraph 9.02.A, delete the words "provided Contractor makes no reasonable objection to the replacement engineer"

SC-9.09 – Insert the following after Paragraph 9.09.A:

B. Review or approval by Owner or its agents of Contractor's means, methods, techniques, procedures or submittals, or of any other aspect of Contractor's Work or services shall not relieve Contractor of its sole liability for any damages resulting from or arising out of defects or deficiencies in the Contractor's means, methods, techniques, procedures or submittals, or of any other aspect of Contractor's Work or services.

SC 10.01.A - Add the following paragraphs after Paragraph 10.01.A:

1. Engineer's Reimbursement Rates: Up to $285 per hour, based on a 3.10 multiplier times the direct labor rate in accordance with the Owner's Agreement with Engineer.

SC-10.03 - Add the following paragraphs after Paragraph 10.03.A:

B. Resident Project Representative (RPR) will be furnished by Owner. The responsibilities, authority, and limitations of the RPR are limited to those of Engineer in accordance with Paragraph 10.08 and as set forth elsewhere in the Contract Documents and are further limited and described below.

C. Responsibilities and Authority:

1. Schedules: Review and monitor Progress Schedule, Schedule of Submittals, and Schedule of Values prepared by Contractor and consult with Engineer concerning acceptability.

2. Conferences and Meetings: Conduct or attend meetings with Contractor, such as preconstruction conferences, progress meetings, Work conferences and other Project related meetings.

3. Liaison: (i) Serve as Engineer's liaison with Contractor, working principally through Contractor's authorized representative, and assist in understanding the intent of the Contract Documents; (ii) assist Engineer in serving as Owner's liaison with Contractor when Contractor's operations affect Owner's onsite operations; (iii) assist in obtaining from Owner additional details or information when required for proper execution of the Work.

4. Interpretation of Contract Documents: Inform Engineer when clarifications and interpretations of the Contract Documents are needed and transmit to Contractor clarifications and interpretations as issued by Engineer.

5. Submittals: Receive submittals that are furnished at the Site by Contractor, and notify Engineer of availability for examination. Advise Engineer and Contractor of the commencement of any Work or arrival of materials and equipment at Site, when recognized, requiring a Shop Drawing or Sample if the submittal has not been approved by Engineer.

6. Modifications: Consider and evaluate Contractor's suggestions for modifications in Drawings or Specifications and provide recommendations to Engineer; transmit to Contractor, in writing decisions as issued by Engineer.

7. Review of Work and Rejection of Defective Work: (i) Conduct onsite observations of the Work in progress to assist Engineer in determining if the Work is, in general, proceeding in accordance with the Contract Documents; (ii) inform Engineer and Contractor whenever RPR believes that any Work is defective; (iii) advise Engineer whenever RPR believes that any Work will not produce a completed Project that conforms generally to the Contract Documents or will imperil the integrity of the design concept of the completed Project as a functioning whole as indicated in the Contract Documents, or has been damaged or does not meet the requirements of any inspection test, or approval required to be made; and advise Engineer of that part of the Work in progress that RPR believes should be corrected or rejected or uncovered for observation, or requires special testing, inspection, or approval.

8. Inspections, Tests, and System Startups: (i) Verify tests, equipment and systems startups and operating and maintenance training are conducted in the presence of appropriate personnel, and that Contractor maintains adequate records thereof; (ii) observe, record, and report to Engineer appropriate details relative to the test procedures and system startups; and (iii) accompany visiting inspectors representing public or other agencies having jurisdiction over the Project, record the results of these inspections, and report to Engineer.

9. Records: (i) Maintain records for use in preparing Project documentation; (ii) keep a diary or log book recording pertinent Site conditions, activities, decisions and events; (iii) record names, addresses, fax numbers, e-mail addresses, web site locations, and telephone numbers of Contractors, Subcontractors, and major Suppliers of materials and equipment.

10. Reports: (i) Furnish Engineer periodic reports of progress of the Work and of Contractor's compliance with the Progress Schedule and Schedule of Submittals; (ii) immediately notify Engineer of the occurrence of Site accidents, emergencies, acts of God endangering the Work, damage to property by fire or other causes, or the discovery of any Hazardous Environmental Condition; and (iii) assist

Engineer in drafting proposed Change Orders, Work Change Directives, and Field Orders; obtain backup material from Contractor as appropriate.

11. Payment Requests: Review Applications for Payment with Contractor for compliance with the established procedure for their submission and forward with recommendations to Engineer, noting particularly the relationship of the payment requested to the Schedule of Values, Work completed, and materials and equipment delivered at the Site but not incorporated in the Work.

12. Certificates, Operation and Maintenance Manuals: During the course of the Work, verify materials and equipment certificates and operation and maintenance manuals and other data required by Specifications to be assembled and furnished by Contractor are applicable to the items actually installed and in accordance with the Contract Documents, and have these documents been delivered to Engineer for review and forwarding to Owner prior to payment for that part of the Work.

13. Completion: (i) Participate in a Substantial Completion inspection; assist in determination of Substantial Completion and the preparation of lists of items to be completed or corrected; (ii) Participate in a final inspection in the company of Engineer, Owner, and Contractor and prepare a final list of items to be completed and deficiencies to be remedied; and (iii) observe whether items on final list have been completed or corrected, and make recommendations to Engineer concerning acceptance.

D. Limitations of Authority: Resident Project Representative will not:

1. have authority to authorize a deviation from Contract Documents or substitution of materials or equipment, unless authorized by Engineer; or

2. undertake any of the responsibilities of Contractor, Subcontractors, Suppliers, or Contractor’s authorized representative; or

3. advise on, issue directions relative to, or assume control over an aspect of the means, methods, techniques, sequences, or procedures of Contractor’s work unless such advice or directions are specifically required by the Contract Documents; or

4. advise on, issue directions regarding, or assume control over safety practices, precautions, and programs in connection with the activities or operations of Owner or Contractor; or

5. participate in specialized field or laboratory tests or inspections conducted offsite by others, except as specifically authorized by Engineer; or

6. accept Shop Drawings or Samples from anyone other than Contractor; or

7. authorize Owner to occupy the Project in whole or in part.

SC-11.05.B - Add the following to the end of Paragraph 11.05.B:

All requests for time extensions shall be supported by Schedule analysis showing the effect on the entire Project taking into account concurrent Work and the critical path, including float. Partial demonstration of impact on particular operations only will not be acceptable to show the criticality of any event on the Project Schedule as a whole.

SC-11.05 - Add the following paragraph after Paragraph 11.05.B:

C. Use of Float:

1. A claim for an adjustment of Contract Times (or Milestones), otherwise allowable under the Contract Documents, shall be granted only when the time lost or gained exceeds the float for the activity at the time of the event giving rise to the claim. Float, the amount of time between the early start date and the late start date, or the early finish date and the late finish date, is jointly owned by both Owner and Contractor whether expressly disclosed or implied in any manner.

2. Contractor shall not use float suppression techniques (including, but not limited to, preferential sequencing caused by late starts of follow-up trades, unreasonably small crews, extended durations, or imposed dates) in information provided to Engineer.

SC-11.06.A.3 – Add the following paragraphs after Paragraph 11.06.A.3 :

4. Contractor to use Change Proposal form acceptable to Engineer. Contractor to submit Change Proposal form or document for approval prior to submission of first Change Proposal

SC-11.07 - Add the following paragraphs after Paragraph 11.07.B:

C. In signing a Change Order, the Owner and Contactor acknowledge and agree that:

1. The stipulated compensation (i.e., adjustments to the Contract Price or Contract Times, or both) set forth in the Change Order constitutes full payment for (i) the Cost of the Work covered by the Change Order, including but not limited to labor, material, equipment, supervision, subcontract, direct, and indirect costs (ii) Contractor's fee for overhead and profit, including but not limited to extended overhead (iii) interruption of progress schedules, (iv) all costs, delay and impact, including cumulative impact of all prior Change Orders, arising out of related to the subject matter of the Change Order, on the Work under the Contract Documents, and (v) all other costs or damages, whether known or unknown;

2. they intend for the Change Order to constitute a full and final settlement of all matters related to the change in the Work and an accord and satisfaction of all impacts that may be suffered by Contractor due to the change(s) in the Work and the Change Order shall be deemed to compensate Contractor for such change(s);

3. by executing the Change Order, Contractor agrees to defend, indemnify, reimburse and hold harmless Owner and Engineer and their officers, agents and employees from, for and against any and all claims of any kind by any

Subcontractor or Supplier of any tier based upon the subject matter of any claim released by Contractor in the Change Order;

4. the individual signing the Change Order for Contractor represents by signing that he or she is fully authorized to bind Contractor; and

5. except as otherwise provided in the Change Order, the Contract, as amended, between Owner and Contractor remains in full force and effect.

D. A copy of the Change Order form that will be used on the Project is attached as Exhibit A to the Supplementary Conditions.

SC-11.09 – Add the following paragraphs to ARTICLE 11 – AMENDING THE CONTRACT DOCUMENTS; CHANGES IN THE WORK:

11.09 Cost Reduction Incentive

A. Contractor may submit cost reduction proposals to the Engineer for modifying the plans, Specifications, or other requirements of this Contract for the sole purpose of reducing the total cost of construction. The cost reduction proposal shall not impair the essential functions or characteristics of the Project, including, but not limited to, service life, economy of operation, ease of maintenance, desired appearance, or safety standards.

B. Cost reduction proposals shall contain the following information:

1. A description of both the existing Contract requirements and the proposed changes.

2. An itemization of the change in Contract requirements if the cost reduction proposal is adopted.

3. A detailed estimate of the cost of performing the Work under the existing Contract and under the proposed change. The detailed estimates shall include all labor, material, equipment, Subcontractor, supervision, overhead and fee costs in sufficient detail as Owner deems appropriate and in accordance with Article 11. The detailed estimates shall also include adequate substantiation for such costs in the form of quantity surveys and Supplier and Subcontractor quotations. If requested by Owner, Contractor shall require any Subcontractors to provide detailed estimates in accordance with this Paragraph.

4. A CPM schedule analysis of the time associated with performing the Work under the existing Contract and under the proposed change.

5. A statement of the time within which the Engineer must make a decision on the cost reduction proposal.

C. Engineer will not be liable to the Contractor for any failure to accept or act upon any cost reduction proposal submitted, nor for any delays to the Work attributable to any such cost reduction proposal.

D. Contractor shall continue to perform the Work in accordance with the requirements of the Contract until an executed Change Order, incorporating the cost reduction proposal has been issued. If an executed Change Order has not been issued by the date indicated in the Contractor's cost reduction proposal, or such other date as the Contractor may

subsequently have specified in writing, such cost reduction proposal shall be deemed rejected.

E. Engineer shall be the sole judge of the acceptability of a cost reduction proposal and of the estimated net savings in construction costs from the adoption of all or any part of such proposal. In determining the estimated net savings, the Engineer reserves the right to disregard Contract bid prices if, in the judgment of the Engineer, such prices do not represent a fair measure of the value of the Work to be performed or deleted.

F. Engineer reserves the right to require the Contractor to share in the Owner's costs of investigating a cost reduction proposal submitted by the Contractor. Where such condition is imposed, the Contractor shall indicate acceptance in writing, and such acceptance shall constitute full authority for the Engineer to deduct amounts payable to the Contractor from any monies due the Contractor under the Contract.

G. If Contractor's cost reduction proposal is accepted in whole or in part, such acceptance will be by a Contract Change Order. The Change Order shall specifically state that it is executed pursuant to this Section. Such change order will incorporate the changes in the Contract Documents which are necessary to implement the cost reduction proposal, and shall include any conditions upon which the Engineer's approval is based. The Change Order shall set forth the estimated net savings in the cost of performing the Work attributable to the cost reduction proposal, and shall further provide that the Contract cost be adjusted by crediting the Owner with 50 percent of the net cost savings; provided, however, that the aggregate of Contractor's share of such savings shall not exceed one percent of the Contract Price. After the aforementioned aggregate limit has been reached, the Owner shall be credited 100 percent of net cost savings. The amount specified to accrue to the Contractor in the Change Order for a cost reduction proposal, if any, shall constitute full compensation to the Contractor for all Work associated with the cost reduction proposal.

H. Acceptance of the cost reduction proposal and performance of the Work thereunder shall not extend the time of the Contract unless specifically provided for in the Contract Change Order incorporating the cost reduction proposal.

I. Owner expressly reserves the right to adopt a cost reduction proposal for general use on contracts administered by the Owner when it determines that the cost reduction proposal is suitable for application to other contracts. When an accepted cost reduction proposal is adopted for general use, only the Contractor who first submitted such proposal will be eligible for compensation, and only to those contracts awarded to the Contractor prior to submission of the accepted cost reduction proposal. Cost reduction proposals similar or identical to previously submitted proposals will be eligible for consideration and compensation if the previously submitted cost proposal was not adopted for general application. The Owner or any other public agency shall have the right to use all or any part of a cost reduction proposal without obligation or compensation of any kind to the Contractor.

J. Contractor shall bear all costs to revise all bonds for the Project to include the cost reduction incentive proposal work.

SC-12.01.B Delete Paragraph 12.01.B in its entirety and replace it with the following:

B. Submittal of Claim: Contractor shall deliver Claims directly to Owner promptly (but in no event later than 30 days) after the start of the event giving rise thereto; in the case of appeals regarding Change Proposals within 30 days of the decision under appeal. Owner shall deliver Claims directly to Contractor. The party submitting the Claim shall also furnish a copy to the Engineer, for its information only. The responsibility to substantiate a Claim shall rest with the party making the Claim. In the case of a Claim by Contractor seeking an increase in the Contract Times or Contract Price, or both, Contractor shall certify that the Claim is made in good faith, that the supporting data are accurate and complete, and that to the best of Contractor's knowledge and belief the amount of time or money requested accurately reflects the full amount to which Contractor is entitled.

SC-12.01 Delete Paragraph 12.01.D in its entirety and replace it with the following:

D. Executive Negotiation

1. Within 10 days of the delivery of notice of appeal to Engineer's written decision regarding a Claim, dispute or other matter, senior representatives of at least Owner and Contractor, having authority to settle the dispute, and Engineer shall meet at a mutually acceptable time and place, and thereafter as often as they reasonably deem necessary, to exchange relevant information and to attempt to resolve the dispute.

2. In the event a mutually acceptable decision cannot be reached through executive negotiation within 20 days of the appealing party's notice, or mutually agreeable longer period, or if the party receiving such notice will not meet within 10 days, Owner or Contractor may make a written declaration, delivered to the other party and Engineer, that the executive negotiation is deemed unsuccessful and may initiate further dispute resolution measures in accordance with Article 17.

SC-12.01.G - Delete the words "direct" and "mediation," in the first sentence.

SC-12.02 – Add the following paragraph to ARTICLE 12 –CLAIMS:

12.02 Right to Audit

A. If the Contractor submits a Claim to the Owner for additional compensation, the Owner shall have the right, as a condition to considering the Claim, and as a basis for evaluation of the Claim, and until the Claim has been settled, to audit the Contractor's books. This right shall include the right to examine books, records, documents, and other evidence and accounting procedures and practices, sufficient to discover and verify all direct and indirect costs of whatever nature claimed to have been incurred or anticipated to be incurred and for which the Claim has been submitted. The right to audit shall include the right to inspect the Contractor's plant, or such parts thereof, as may be or have been engaged in the performance of the Work. The Contractor further agrees that the right to audit encompasses all subcontracts and is binding upon Subcontractors. The rights to examine and inspect herein provided for shall be exercisable through such representatives, as the Owner deems desirable during the Contractor's normal business

hours at the office of the Contractor. The Contractor shall make available to the Owner for auditing, all relevant accounting records and documents, and other financial data, and upon request, shall submit true copies of requested records to the Owner.

SC-13.01.B.1 – Delete Paragraph 13.01.B.1 in its entirety and replace it with the following:

1. Labor costs for employees in the direct employ of Contractor in the performance of the Work will be the actual cost for wages in accordance with the Oregon Bureau of Labor and Industries (BOLI) Prevailing Wage Rates for Public Works Contracts in Oregon for each craft or type of workers performing the Work at the time the Work is done, plus BOLI's established Fringe Rate for employer payments of payroll taxes, worker compensation insurance, liability insurance, health and welfare, pension, vacation, apprenticeship funds, and other direct costs resulting from Federal, State or local laws, as well as assessments or benefits required by lawful collective bargaining agreements. Labor costs for equipment operators and helpers will be paid only when such costs are not included in the invoice for equipment rental. The labor costs for foremen and superintendents shall be proportioned to all of their assigned Work and only that applicable to extra Work shall be paid.

SC-13.01.B.4 – In Paragraph 13.01.B.4, delete the word "special" and replace with the word "technical".

SC-13.01.B.5.c - Delete Paragraph 13.01.B.5.c in its entirety and replace it with the following:

c. Rentals of construction equipment at the rental rate listed for such equipment or from rate sheets from local rental companies. Such rental rate will be used to compute payments for equipment whether the equipment is under the Contractor's control through direct ownership, leasing, renting, or another method of acquisition. The rental rate to be applied for use of each item of equipment will be the rate resulting in the least total cost to the Owner for the total period of use. If it is deemed necessary by the Contractor to use the equipment not listed by the references specified herein, an equitable rental rate for the equipment will be established by the Engineer. The Contractor may furnish cost data which might assist the Engineer in the establishment of the rental rate. Payment shall be subject to the following:

1) Payment for equipment which is already on the Project Site and which is used in the completion of extra Work will not be allowed;

2) All equipment shall, in the opinion of the Engineer, be in good working condition and suitable for the purpose for which the equipment is to be used;

3) Before construction equipment is used on the extra Work, the Contractor shall plainly stencil or stamp an identifying number thereon at a conspicuous location, and shall furnish to the Engineer, in duplicate, a description of the equipment and its identifying number;

4) Unless otherwise specified, manufacturer's ratings and manufacturer approved modifications shall be used to classify equipment for the determination of applicable rental rates. Equipment which has no direct power unit shall be powered by a unit of at least minimum rating recommended by the manufacturer;

5) Individual pieces of equipment or tools having a replacement value of $500 or less, whether or not consumed by use, will be considered to be small tools and no payment will be made therefore; and

6) Rental time will not be allowed while equipment is inoperative due to breakdowns. The rental time to be paid for equipment at the Site will be the time the equipment is in productive operation on the extra Work being performed and, in addition, will include the time required to move the equipment to the location of the extra Work and return it to the original location or to another location; except, that moving time will not be paid if the equipment is used on other than the extra Work, even though located at the Site of the extra Work. Loading and transporting costs will be allowed, in lieu of moving time, when the equipment is moved by means other than its own power, except that no payment will be made for loading and transporting costs when the equipment is used at the Site of the extra Work on other than the extra Work.

SC-13.01.C.5 – Insert the words ", including lost opportunity costs" between the words "kind" and "and" in the second line.

SC-14.02.B - Replace "Owner shall" with "Owner shall perform testing and inspections itself or shall" at the beginning of this paragraph.

SC-14.02.D - Add the following after Paragraph 14.02.D.5:

6. retesting required because of nonconformance to the requirements of the Contract Documents

SC-14.02 - Add the following paragraph at the end of Paragraph 14.02.F:

G. Tests required by Contract Documents to be performed by Contractor that require test certificates be submitted to Owner or Engineer for acceptance shall be made by an independent testing laboratory or agency licensed or certified in accordance with Laws and Regulations and applicable state and local statutes. In the event state license or certification is not required, testing laboratories or agencies shall meet the following applicable requirements:

1. Basic requirements of ASTM E329, "Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection" as applicable.

2. Calibrate testing equipment at reasonable intervals by devices of accuracy, traceable to the National Institute of Standards and Technology or accepted values of natural physical constants.

SC-15.01.B - Add the following subparagraph after Paragraph 15.01.B.3:

4. Schedules and Data: During the progress of the Work, each Application for Payment shall be accompanied by Contractor's updated schedule of operations, or progress report, with Shop Drawings schedules, procurement schedules, value of material on hand included in the application, and other data specified in Section 01330, Submittal Procedures, or reasonably required by Engineer.

5. Unless otherwise indicated in Contract Documents, partial payment for equipment shall be as follows:

a) 20 percent upon final approval of Shop Drawings by Engineer or Owner.
b) 70 percent upon delivery of goods and O&M manual(s).
c) 10 percent upon startup and final acceptance of goods by Engineer or Owner.

SC-15.01.C - Replace "10" with "15" at the beginning of this paragraph.

SC-15.01.D - Delete Paragraph 15.01.D in its entirety and replace it with the following:

D. Payment Becomes Due:

Thirty days after presentation of the Application for Payment to Engineer or 15 days after approval of Application for Payment by Owner, whichever comes first, the amount recommended will (subject to the provisions of Paragraph 15.01.E) become due and when due will be paid by Owner to Contractor. The Engineer shall have 15 days from receipt of Application for Payment to notify Contractor if all or part of the Application for Payment is in dispute. The Application for Payment is deemed approved by Owner when Owner makes payment.

SC-15.01.E.1.e - Add the following immediately after Paragraph 15.01.E.1.e:

, including extra cost of inspection made necessary by delayed Work by Contractor under Article 4.05

SC 15.03.A Add the following to the end of Paragraph 15.03.A:

Substantial Completion is further defined as (i) that degree of completion of the Project's operating facilities or systems sufficient to provide Owner the full time, uninterrupted, and continuous beneficial operation of the Work; (ii) all required functional, performance and acceptance or startup testing has been successfully demonstrated for all components, devices, equipment, and instrumentation and control to the satisfaction of Engineer in accordance with the requirements of the Specifications; (iii) all inspections required have

been completed and identified critical defective Work has been replaced or corrected; and (iv) all appurtenant operations and maintenance features (e.g., hose bibs, drainage systems, etc.) and safety features (e.g., handrails, motor guards, etc.) have been installed and are functional. Project phases are defined in Section 01140, Work Restrictions.

1. Conditions precedent to Substantial Completion of the Work and Engineer's issuance of a Certificate of Substantial Completion shall include:

a. Conformance with all training services requirements and deliverables.

b. Acceptance of all preliminary operation and maintenance manuals by Owner and Engineer.

c. Submittal of current record documents to Owner and Engineer.

d. Correction of all state, local, and other regulatory agencies defective Work lists.

e. Submittals have been received and approved by Engineer including, but not limited to, the following:

1). Approved Shop Drawings.

2). Record Drawings and Specifications.

3). Electrical testing and wiring diagram.

4). Equipment data forms.

5). Manufacturer's certificates of proper installation.

6). Factory test reports.

7). Commissioning, testing and startup reports.

SC 15.03.B - Add the following subparagraph to Paragraph 15.03.B:

1. If some or all of the Work has been determined not to be at a point of Substantial Completion and will require re-inspection or re-testing by Engineer, the cost of such re-inspection or re-testing, including the cost of time, travel and living expenses, shall be paid by Contractor to Owner. If Contractor does not pay, or the parties are unable to agree as to the amount owed, then Owner may impose a reasonable set-off due under Article 15.01.E Reductions in payment by Owner

SC-15.06.C – The term "Final Completion" in the Agreement means that for the Work or designated portion thereof to be achieved, (1) Substantial Completion of the Work or designated portion thereof must have been achieved, (2) the Owner must have received a final certificate of occupancy and all other governmental approvals necessary and required for the Owner to occupy or utilize the Work or designated portion thereof for its intended purpose, (3) the Contractor must have submitted all warranties, operating and maintenance manuals, As-Built Drawings and Specifications, keys and other submittals required for the Work or designated portion thereof and (4) the Contractor otherwise must have fully performed and completed all of its other obligations required for Final Completion under the Contract Documents with respect to the Work or designated portion thereof.

SC-15.07.A – Delete Paragraph 15.07.A in its entirety.

SC-16.04 –Delete Paragraph 16.04 in its entirety.

SC-17.01. Delete Paragraph 17.01 in its entirety and replace it with the following:

17.01 Mediation, Followed by Binding Arbitration:

A. All appealed or unsettled Claims, disputes or other matters between Owner and Contractor arising out of or relating to the Contract Documents or the breach thereof, (except for Claims which have been waived by the making or acceptance of final payment as provided by Paragraph 15.06) shall first be submitted to mediation under the Construction Industry Mediation Rules of the American Arbitration Association then obtaining subject to the limitations of this Article 17. The mediator of any claim, dispute or other matter submitted to mediation under this Agreement shall not serve as arbitrator of such Claim, dispute, or other matter unless otherwise agreed.

B. Should the mediation be unsuccessful, such Claim, dispute or other matter (except for Claims which have been waived by the making or acceptance of final payment as provided by Paragraph 15.06) shall be decided by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association subject to the limitations of this Article 17.

C. This Agreement so to mediate or to arbitrate and any other agreement or consent to mediate or to arbitrate entered into in accordance with these Contract Documents will be specifically enforceable under the prevailing law of any court having jurisdiction.

D. No demand for mediation or arbitration of any appealed or unsettled Claim, dispute or other matter that is required to be referred to Engineer initially for decision in accordance with Article 11 and 12 will be made later than 10 days after the date the executive negotiation has been declared unsuccessful by Owner or Contractor; and the failure to demand mediation or arbitration within said 10 days' period will result in Engineer's decision being final and binding upon Owner and Contractor. If Engineer renders a further decision after mediation or arbitration proceedings have been initiated, the decision may be entered as evidence but will not supersede the proceedings, except where the decision is acceptable to the parties concerned. Time deadlines specified above apply to mediation (after the executive negotiation has been declared unsuccessful by Owner or Contractor) and arbitration (after the mediation process has been declared unsuccessful by Owner or Contractor.)

E. Notice of the demand for mediation or arbitration will be filed in writing with the other party to the Agreement and with the American Arbitration Association, and a copy will be sent to Engineer for information. The demand for mediation will be made within the ten day periods specified in Paragraph 17.01.D as applicable, and in all other cases within a reasonable time after the unsettled Claim, dispute or other matter has arisen, and in no event shall any such demand be made after the date when institution of legal or equitable proceedings based on such unsettled Claim, dispute or other matter would be barred by the applicable statute of limitations.

F. Except as provided in Paragraphs 17.01.G and H below, no arbitration arising out of or relating to the Contract Documents shall include by consolidation, joinder or in any other manner any other person or entity who is not a party to the Contract unless:

1. the inclusion of such other person or entity is necessary if complete relief is to be afforded among those who are already parties to the arbitrations, and

2. such other person or entity is substantially involved in a question of law or fact which is common to those who are already parties to the arbitration and which will arise in such proceedings, and

3. the written consent of the other person or entity sought to be included and the Owner has been obtained for such inclusion, which consent shall make specific reference to this paragraph; but no such consent shall constitute consent to arbitration of any appealed or unsettled Claim, dispute or other matter not specifically described in such consent or to arbitration with any party not specifically identified in such consent.

G. Notwithstanding Paragraph 17.01.F, if an appealed or unsettled Claim, dispute or other matter between Owner and Contractor involves any allegations relating to the design, Owner may join Engineer as a party to the mediation or arbitration between Owner and Contractor hereunder.

H. Notwithstanding Paragraph 17.01.F, if an appealed or unsettled Claim, dispute or other matter between Owner and Contractor involves the Work of a Subcontractor, either Owner or Contractor may join such Subcontractor as a party to the mediation or arbitration between Owner and Contractor hereunder. Contractor shall include in all subcontracts required by Paragraph 7.06.G of the General Conditions a specific provision whereby the Subcontractor consents to being joined in mediation or arbitration between Owner and Contractor involving the Work of such Subcontractor. Nothing in this Paragraph 17.01.H nor in the provision of such subcontract consenting to joinder shall create any Claim, right or cause of action in favor of Subcontractor and against Owner, Engineer or Engineer's Consultants that does not otherwise exist.

I. At the conclusion of the mediation process specified herein, the Contractor will, as a condition of taking any further action with respect to any Claim, be required to certify that the amount of the Claim is its best good faith estimate of the amount due ("Certified Claim"). Owner will certify its final offer of settlement ("Final Offer").

J. The results of successful mediation will be implemented by a Change Order. The award rendered by the arbitrators will be final, judgement may be entered upon it in any court having jurisdiction thereof, and will not be subject to modification or appeal.

SC-17.03. Add the following new paragraph immediately after Paragraph 17.02:

17.03 Attorney Fees

The costs of any binding dispute resolution procedure shall be borne by the non-prevailing Party, as determined by the adjudicator of the dispute.

In the event Contractor pursues the Claim, Contractor will be entitled, in addition to whatever recovery it has on the Claim, to be reimbursed its reasonable attorney's fees incurred in the same proportion it was successful based on the difference between its Certified Claim compared to the Owner's Final Offer. Conversely, Owner will be entitled to be reimbursed its reasonable attorney's fees incurred in proportion to the amount that Contractor was unsuccessful based on the difference between its Certified Claim compared to the Owner's Final Offer. For example, if Contractor recovers 40 percent of the difference between its Certified Claim and the amount of the Owner's Final Offer, Contractor would be entitled to recover 40 percent of its reasonable attorney's fees incurred in the prosecuting the Claim and the Owner would be entitled to recover 60 percent of its reasonable attorney's fees incurred in defending the Claim. On the other hand, if the Contractor recovers 60 percent of the difference between its Certified Claim and the amount of the Owner's Final Offer, Contractor would be entitled to recover 60 percent of its reasonable attorney's fees in prosecuting the Claim and the Owner would be entitled to recover 40 percent of its reasonable attorney's fees incurred in defending the Claim. The Certified Claim and the Final Offer will be admissible in any dispute resolution proceeding.

The supplements listed below and attached after the "End of Section", are a part of this Section:

1. Exhibit A, Contract Change Order
2. Exhibit B, Standard Contract Clauses, Oregon Revised Statutes

END OF SECTION

EXHIBIT A

CONTRACT CHANGE ORDER **NO:**

To Contractor:		Date:	
Project:	Durham WRRF Phase 6B Digester	Project No.	7203
Owner:	Clean Water Services	Change Order Contract No.	
Engineer:			

The following change(s) to the Contract are hereby ordered (use additional pages if required):

Attachments (List Supporting Documents):

Changes to Contract Amount and Contract Times:

The stipulated compensation (i.e., adjustments to the Contract Price or Contract Times, or both) set forth in this Change Order constitutes full payment for (i) the Cost of the Work covered by the Change Order, including but not limited to labor, material, equipment, supervision, subcontract, direct, and indirect costs (ii) Contractor's fee for overhead and profit, including but not limited to extended overhead (iii) interruption of progress schedules, (iv) all costs, delay and impact, including cumulative impact of all prior Change Orders, arising out of related to the subject matter of the Change Order, on the Work under the Contract Documents, and (v) all other costs or damages, whether known or unknown.

This Change Order constitutes a full and final settlement of all matters related to the change in the Work and an accord and satisfaction of all impacts that may be suffered by Contractor due to the change(s) in the Work and the Change Order shall be deemed to compensate Contractor for such change(s).

By executing this Change Order, Contractor agrees to defend and indemnify, reimburse and hold harmless Owner and Engineer and their officers, agents, and employees from, for and against any and all claims of any kind by any subcontractor or supplier of any tier based upon the subject matter of any claim released by Contractor in the Change Order. Except as otherwise provided in this Change Order, the Contract, as amended, between Owner and Contractor, remains in full force and effect.

This Change Order may be executed in several counterparts, each of which will be an original, all of which will constitute one and the same instrument. An electronic signature will be considered an original. The individuals signing this Change Order certify that they are authorized to execute this Change Order on behalf of Contractor, Owner and Engineer if required, respectively.

Contract Amount		Contract Times (Calculate Days)		
Original Amount:	_____	Original Contract Time:		
Previous Contract Change Orders:	_____	Substantial Completion	_____	Days
Previous Contract Change Percentage:	_____	Final Completion	_____	Days
This Contract Change Order:	_____	Previous Contract Change Orders:		
This Contact Change Percentage:	_____	Substantial Completion	_____	Days
	_____	Final Completion	_____	Days
Revised Contract Amount:	_____	This Contract Change Order:		
Contract Change Order Percentage:	_____			Days
		Substantial Completion	_____	
		Final Completion	_____	Days
		Revised Contract Time:		
				Days
		Substantial Completion	_____	
		Final Completion	_____	Days

The Revised Date of Substantial Completion is:

_____ , 20 _____

The Revised Date of Final Completion is:

_____ , 20 _____

This Change Order is Issued in Accordance with Paragraph SC – 11.07 of the Supplementary Conditions.

Owner	Contractor	Engineer Recommendation
By:_____	By:_____	By:_____
Date:_____	Date:_____	Date:_____

EXHIBIT B

STANDARD CONTRACT CLAUSES, OREGON REVISED STATUTES

The following paragraphs include without limitation the standard contract clauses that are required in every public contract in accordance with the Oregon Revised Statutes and for which Contractor may be responsible under Paragraph 7.10 of the General Conditions. Contractor shall include any other standard contract clauses required by federal, state, and local laws, ordinances and regulations. The Contract shall include by reference any other standard contract clauses required by federal, state and local laws, ordinances and regulations.

1. *Prompt Payment:* Contractor shall promptly pay all of its obligations arising out of or in connection with the Work, including, but not limited to, payments (1) to all persons, as due, supplying to Contractor labor, equipment, services or material for the performance of the Contract, (2) of all contributions or amounts due the Industrial Accident Fund from Contractor or any Subcontractor incurred in the performance of the Contract, and (3) to the Department of Revenue of all sums withheld from employees under ORS 316.167.

2. *Prompt Payment Policy:* It is the policy of the State of Oregon that all payments due on a public improvement contract and owed by a contracting agency shall be paid promptly. No public *contracting* agency is exempt from the provisions of ORS 279C.570.

3. *Contractor's Failure to Make Prompt Payment:* If, upon reasonable concern by Owner that Contractor has failed, neglected or refused to make prompt payment of any claim for labor, equipment, services or materials furnished to Contractor or a Subcontractor by any person in connection with the Project as such claim becomes due, Owner may pay such claim to the person furnishing the labor, equipment, services or materials and charge the amount of the payment against funds due or to become due Contractor under the Contract. Owner reserves the right to make payments directly or by multiple-payee check and Contractor hereby consents to such direct and multiple-payee check payments. Upon Owner's request, Contractor shall furnish to Owner the information required to facilitate such payments with each application for payment, including (1) names, addresses, and telephone numbers of persons making any such claim for labor, equipment, services or material, and (2) a complete listing of outstanding amounts owed to all such persons.

4. *Contractor's and First-Tier Subcontractor's Failure to Make Payment After Payment From Owner; Interest Penalty:* If Contractor or a first-tier Subcontractor fails, neglects or refuses to make payment to a person furnishing labor, equipment, services or materials in connection with the Project within 30 days after receipt of payment from Owner or Contractor, Contractor or first-tier Subcontractor shall owe the person the amount due plus interest charges commencing at the end of the 10-day period that payment is due under ORS 279C.580(4) and ending upon final payment, unless payment is subject to a good faith dispute as defined in ORS 279C.580. The rate of

interest charged to Contractor or first-tier Subcontractor on the amount due shall equal nine percent per annum The amount of interest may not be waived.

5. *Construction Contractors Board Complaint:* If Contractor or a Subcontractor fails, neglects or refuses to make payment to a person furnishing labor, equipment, services or materials in connection with the Project, the person may file a complaint with the Construction Contractors Board, unless payment is subject to a good faith dispute as defined in ORS 279C.580.

6. *Continuing Liability of Contractor and Surety:* Payment by Owner of a claim in the manner authorized in this paragraph does not relieve Contractor or Contractor's surety from obligation with respect to any unpaid claims.

7. *Prevailing Rate of Wage*: This Project is a public works project subject to the prevailing wage rate requirements in ORS 279C.800 to ORS 279C.870. Contractor and any Subcontractors shall comply with ORS 279C.838 and ORS 279C.840. Workers in each trade or occupation that Contractor, Subcontractors or other person who is a party to the Agreement uses in performing all or a part of the Agreement for this Project shall not be paid less than the minimum hourly rate of wage for such workers incorporated by reference in Section 00810 of the specifications for the Agreement.

8. *Fee to* be *Paid to BOLI:* Owner will pay the required fee to the Commissioner of the Bureau of Labor and Industries pursuant to the provisions of ORS 279C.825.

9. *Compliance with Laws/Tax Laws*: Contractor shall comply with all applicable federal, state, and local laws, statutes, codes, regulations, rules, orders, and rulings as well as all applicable construction industry standards, including without limitation, those governing labor, materials, equipment, construction procedures, safety, health, sanitation, and the environment. Contractor agrees to indemnify, hold harmless, reimburse, and defend Owner from and against any penalties or liabilities arising out of violations of such obligations by Contractor or its Subcontractors or Suppliers at any tier. Contractor must also comply with all Oregon tax laws.

10. *Employee Drug Testing Program:* Contractor shall demonstrate that an employee drug testing program is in place and shall remain in place through the completion of the Work of the Project.

11. *Work Day/Work Week:* No person shall be employed for more than 10 hours in any one day, or 40 hours in any one week, except in cases of necessity, emergency, or where the public policy absolutely requires it, and in such cases, except for cases of contracts for personal services as defined in ORS 279C.100, the employee shall be paid at least time and a half pay (1) for all overtime in excess of 8 hours a day or 40 hours in any one week when the work week is five consecutive days, Monday through Friday, (2) for all overtime in excess of 10 hours a day or 40 hours in any one week when the work is four consecutive days, Monday through Friday, and (3) for all work performed on Saturday, and on any legal holiday specified in ORS 279C.540. Contractor shall pay employees at least time and a half pay for work the employees perform under the

Contract on the legal holidays specified in a collective bargaining agreement or in ORS 279C.540 (1)(b)(B) to (G) and for all time the employees work in excess of 10 hours in any one day or in excess of 40 hours in any one week, whichever is greater.

12. *Prohibition Against Retaliation*. Contractor may not prohibit any of Contractor's employees from discussing the employee's rate of wage, salary, benefits or other compensation with another employee or another person and may not retaliate against an employee who discusses the employee's rate of wage, salary, benefits or other compensation with another employee or another person.

13. *Discrimination*: As required by ORS 279C.520, Contractor shall comply with ORS 652.220 and shall not discriminate against any of Contractor's employees in the payment of wages or other compensation for work of comparable character, the performance of which requires comparable skills, or pay any employee at a rate less than another for comparable work, based on an employee's membership in a protected class as defined in ORS 652.220. Contractor shall comply with the prohibition set forth in ORS 652.220, that compliance is a material element of the Contract and that a failure to comply is a breach that entitles Owner to terminate the Contract for cause.

14. *Notice of Required Work Hours*: Contractor, each Subcontractor and each lower-tier Subcontractor must give notice to its employees in writing, either at the time of hire or before commencement of Work, or by posting a notice in a location frequented by its employees, of the number of hours per day and days per week that the employees may be required to work.

15. *Claims for Overtime*: Any worker employed by Contractor shall be foreclosed from the right to collect for any overtime provided in ORS 279C.540 unless a claim for payment is filed with Contractor within 90 days from the completion of the Contract, provided Contractor has: (1) Caused a circular clearly printed in boldfaced 12-point type and containing a copy of this section to be posted in a prominent place alongside the door of the timekeeper's office or in a similar place which is readily available and freely visible to any or all workers employed on the Work; (2) Maintained such circular continuously posted from the inception to the completion of the Contract on which workers are or have been employed.

16. *Worker's Compensation:* All employers, including Contractor, that employ subject workers who work under this Contract in the State of Oregon shall comply with ORS 656.017 and provide the required Workers' Compensation coverage, unless such employers are exempt under ORS 656.126. Contractor shall ensure that each of its Subcontractors complies with these requirements.

17. *Prompt Payment for Medical Services:* Contractor shall promptly make payment, as due, to any person, co-partnership, association or corporation, furnishing medical, surgical or hospital care services or other needed care and attention, incident to sickness or injury, to the employees of Contractor, of all sums that Contractor agrees to pay for the services and all moneys and sums that Contractor collected or deducted from the

wages of employees under any law, contract or agreement for the purpose of providing or paying for the services.

18. *Prompt Payment by Contractor and Subcontractors; Interest Penalty:* Contractor shall include in each subcontract for property or services entered into by Contractor with a first-tier subcontractor, including a material supplier, for the purposes of constructing a contract:

A. A payment clause that requires Contractor to make payment to the first-tier subcontractor or Supplier for satisfactory performance under the subcontract within 10 days out of amounts Owner pays to Contractor under the Contract;

B. A clause that requires Contractor to provide a first-tier subcontractor with a standard form that the first-tier subcontractor may use as an application for payment or as another method by which the subcontractor may claim a payment due from the Contractor;

C. A clause that requires Contractor, except as otherwise provided in this paragraph, to use the same form and regular administrative procedures for processing payments during the entire term of the subcontract. Contractor may change the form or the regular administrative procedures the contractor uses for processing payments if the Contractor:

(1) Notifies the subcontractor in writing at least 45 days before the date on which the Contractor makes the change; and

(2) Includes with the written notice a copy of the new or changed form or a description of the new or changed procedure;

D. An interest penalty clause that obligates Contractor, if Contractor does not pay the first-tier subcontractor within 30 days after receiving payment from Owner, to pay the first-tier subcontractor an interest penalty on amounts due in each payment Contractor does not make in accordance with the payment clause included in the subcontract under paragraph A of this subsection. Contractor or a first-tier subcontractor is not obligated to pay an interest penalty if the only reason that Contractor or the first-tier subcontractor did not make payment when payment was due is that Contractor or the first-tier subcontractor did not receive payment from Owner or Contractor when payment was due. The interest penalty:

(1) Applies to the period that begins on the day after the required payment date and that ends on the date on which the amount due is paid; and

(2) Is computed at the rate specified in ORS 279C.515 (2);

E. Contractor, in each of Contractor's subcontracts, will require the first-tier subcontractor to include a payment clause and an interest penalty clause that conforms to the standards of subsection A through D of this section in each of the first-tier subcontractor's subcontracts and to require each of the first-tier subcontractor's subcontractors to include such clauses

in the first-tier subcontractors' subcontracts with each lower-tier subcontractor or supplier; and

F. Contractor shall comply with all of the provisions in ORS 279C.570.

19. *List of Subcontractors/Licensing With Construction Contractors Board:* Before commencing Work, Contractor shall provide to Owner and Engineer a list of all Subcontractors and Suppliers to be involved on the Project. The list shall be attached to the Agreement as an Exhibit. The receipt of such list shall not require Owner or Engineer to investigate the qualifications of proposed Subcontractors and Suppliers, nor shall it waive the right of Owner to later object to or reject any proposed Subcontractor or Supplier. It shall be the responsibility of Contractor to assure that all Subcontractors are duly registered with the Oregon State Construction Contractors Board and have not been declared ineligible to work on a public contract.

20. *Material Salvage:* To the extent the scope of the Work for this Agreement requires demolition, Contractor must salvage or recycle construction and demolition debris, if feasible and cost-effective.

21. *Composting:* To the extent the scope of the Work for this Agreement requires lawn and landscape maintenance, Contractor must compost or mulch yard waste material at an approved site, if feasible and cost-effective.

22. *Environmental and Natural Resources Laws:* Pursuant to ORS 279C.525, the following is a list of Federal, State, and Local agencies that have enacted ordinances or regulations dealing with the prevention of environmental pollution and the preservation of natural resources that may affect the performance of this Agreement. The following list may not include all such agencies that have enacted ordinances or regulations relating to the prevention of environmental pollution and preservation of natural resources.

FEDERAL AGENCIES:
AGRICULTURE, DEPT. OF
FOREST SERVICE
NATURAL RESOURCES CONSERVATION SERVICE
DEFENSE, DEPT. OF
ARMY CORPS OF ENGINEERS
COAST GUARD
ENVIRONMENTAL PROTECTION AGENCY
INTERIOR, DEPT. OF
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF LAND MANAGEMENT
BUREAU OF INDIAN AFFAIRS
BUREAU OF RECLAMATION
LABOR, DEPT. OF
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
TRANSPORTATION, DEPT. OF
FEDERAL HIGHWAY ADMINISTRATION

BUREAU OF MINES
FEDERAL ENERGY REGULATORY COMMISSION
GEOLOGICAL SURVEY
HEALTH AND HUMAN SERVICES, DEPT. OF
HOUSING AND URBAN DEVELOPMENT, DEPT. OF
MINE SAFETY AND HEALTH ADMINISTRATION
MINERALS MANAGEMENT SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OFFICE OF SURFACE MINING, RECLAMATION AND ENFORCEMENT
WATER RESOURCES COUNCIL

STATE AGENCIES:
ADMINISTRATIVE SERVICES, DEPT. OF
AGRICULTURE, DEPT. OF
COLUMBIA RIVER GORGE COMMISSION
CONSUMER AND BUSINESS SERVICES, DEPT. OF
OREGON OCCUPATIONAL SAFETY AND HEALTH DIVISION
ENVIRONMENTAL QUALITY, DEPT. OF
FISH AND WILDLIFE, DEPT. OF
FORESTRY, DEPT. OF
GEOLOGY AND MINERAL INDUSTRIES, DEPT. OF
HUMAN SERVICES, DEPT. OF
LABOR AND INDUSTRIES, BUREAU OF
LAND CONSERVATION AND DEVELOPMENT, DEPT. OF
NATURAL RESOURCES, DEPT. OF
PARKS AND RECREATION, DEPT. OF
STATE FIRE MARSHALL
STATE LANDS, DEPT. OF
WATER RESOURCES DEPARTMENT

LOCAL AGENCIES:
CITY COUNCILS
CIRCUIT COURTS
COUNTY COMMISSIONERS, BOARDS OF
FIRE DISTRICTS
HISTORICAL PRESERVATION COMMISSION
PLANNING COMMISSIONS
PORT DISTRICTS
SPECIAL DISTRICTS

OREGON TRIBAL GOVERNMENTS

23. *Retainage:* The withholding of retainage by Contractor or Subcontractor shall be in accordance with ORS 279C.550 through ORS 279C.570, and ORS 279C.845(7).

24. *Liens:* Contractor shall not permit any lien or claim to be filed or prosecuted against the state, county, school district, municipality, municipal corporation or subdivision thereof, on account of any labor or material furnished.

25. *Notice of Claim on Bond:* The notice of claim required by ORS 279C.600 must be sent by registered or certified mail or hand-delivered no later than 180 days after the day the person last provided labor or furnished materials or 180 days after the worker listed in the notice of claim by the Commissioner of the Bureau of Labor and Industries last provided labor. The notice may be sent or delivered to Contractor or Subcontractor at any place Contractor or Subcontractor maintains an office or conducts business or at the residence of Contractor or Subcontractor. If the claim is for a required contribution to a fund of an employee benefit plan, the notice required by ORS 279C.600 must be sent or delivered within 200 Days after the employee last provided labor or materials. The notice shall be in writing substantially as follows:

_____

(insert the name of Contractor or Subcontractor and the name of the Owner):

Notice is hereby given that the undersigned (here insert the name of the claimant) has a claim for (here insert a brief description of the labor or materials performed or furnished and the person by whom performed or furnished; if the claim is for other than labor or materials, insert a brief description of the claim) in the sum of (here insert the amount) dollars against the (here insert public works bond or payment bond, as applicable) taken from (here insert the name of the principal and, if known, the surety or sureties upon the public works bond or payment bond) for the work of (here insert a brief description of the work concerning which the public works bond or payment bond was taken). Such material or labor was supplied to:

_____

(insert the name of Contractor or Subcontractor)

_____

(here to be signed)

26. Non-resident bidder reporting responsibility to Department of Revenue. Pursuant to ORS 279A.120, when a public contract is awarded to a nonresident bidder and the contract price exceeds $10,000, the bidder shall promptly report to the Department of Revenue on forms to be provided by the department the total contract price, terms of payment, length of contract and such other information as the department may require before the bidder may receive final payment on the public contract. The contracting agency shall satisfy itself that the requirement of this subsection has been complied with before the contracting agency issues a final payment on a public contract.

27. Sanitary Facilities at Construction Projects 654.150:

(1) At the site of every construction project estimated to cost $1 million or more the employer or owner of such place of employment shall provide toilet facilities and

facilities for maintaining personal cleanliness for the use of employees on the construction project. Flush toilets shall be provided and the washing facilities shall consist of warm water, wash basins and soap. A building or a mobile, self-contained unit may be provided for such facilities. The number, types and maintenance of facilities shall conform to minimum standards set by the Director of the Department of Consumer and Business Services.

(2) Subsection (1) of this section does not apply to highway construction or maintenance projects or to electricity, water, sewer or gas transmission facility construction or maintenance projects.

(3) The director may, by order, exempt or partially exempt, individual or classes of construction projects from the requirements of subsection (1) of this section when conditions are such that compliance is impractical or impossible.

END OF SECTION

SECTION 00810
OREGON PREVAILING WAGE RATES

The applicable Oregon minimum prevailing wage rates for such workers in each trade or occupation that Contractor or its Subcontractor or other person who is a party to the Contract uses in performing all or a part of the Contract are contained in the publication *Prevailing Wage Rates for Public Works Contracts* dated July 5, 2025 (see link titled "*July 5, 2025 Prevailing Wage Rate Book*" at https://www.oregon.gov/boli/employers/Pages/prevailing-wage-rates.aspx), available at http://www.oregon.gov/boli and are hereby incorporated herein as of the date these Bidding Documents were first advertised.

END OF SECTION

PART 3

SPECIFICATIONS

SECTION 01012
PARTNERING

PART 1 GENERAL

1.01 GENERAL

A. Owner intends to encourage the foundation of a cohesive partnership between the Owner, Contractor, and Engineer. This partnership will be structured to draw on the strengths of each organization to identify and achieve reciprocal goals.

B. Project partnering recognizes that Owner, Contractor, and Engineer all hold in common the goal of successful completion of this Project, including the following specific goals:

1. Construction that meets the Project performance standards as defined in the Drawing and Specifications of the Contract.
2. Completion of the Project on schedule.
3. Conformance to budgetary requirements and limitations.

C. It is recognized that safety, liability limitations, avoidance of litigation, reputation, good will, and other factors are of significant importance to all parties involved.

D. Through partnering, it is the Owner's intent that the parties will develop an open, communicative relationship such that agreement can be reached on the primary goals of the Project and the methods that will be used to accomplish them. The parties will mutually develop a communication framework and a conflict resolution system to be used throughout the Project.

E. The establishment of a partnering relationship shall not change or modify the Terms and Conditions of the Contract and will not relieve the parties of the requirements of the Contract.

1.02 SCHEDULING

A. Initial Workshop:

1. An initial 2-hour workshop will be scheduled by the Owner within 30 days after the Notice to Proceed, but prior to beginning Work onsite.
2. The workshop will be held at an agreed on location.

B. Additional Sessions: Additional 2-hour partnering sessions shall be held every 3 months throughout the Project in order to confirm the relationship and

assure the partnering effort continues to be successful. These sessions may take the form of a formal evaluation measuring success towards meeting the established goals and objectives.

1.03 ATTENDEES

A. The following persons will be expected to attend all partnering sessions, at a minimum:

1. Contractor:
   a. Project Sponsor (Principal-in-Charge).
   b. Project Manager.
   c. Project Superintendent.
2. Owner:
   a. Division Manager.
   b. Project Manager.
   c. Resident Project Representative(s).
3. Engineer:
   a. Principal-in-Charge.
   b. Project Manager.
   c. Resident Project Representative.

1.04 FACILITATORS

A. A partnering facilitator may be provided by Owner to help establish and monitor the partnering relationship.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01110
SUMMARY OF WORK

PART 1 GENERAL

1.01 THE REQUIREMENTS

A. The Work in this Contract shall consist of performing all Work to fulfill the requirements set forth in the Contract Documents.

1.02 WORK COVERED BY CONTRACT

A. The Work under this Contract shall consist of, but is not limited to the following:

1. Furnishing all labor, materials, and equipment necessary to:
   a. Construct and commission a new 1.3-million gallon, cast-in-place concrete, anaerobic digester with a vertical mixer mixing system.
   b. Install and commission new digester support systems including, but not limited to, a new spiral heat exchanger, heating water pump and piping, digester sludge recirculation pumps and piping, grinders, and associated control valves. Install and commission new redundant digester sludge recirculation pump for existing Digester Complex 2 (DC2) Digesters 1 and 2.
   c. Construct digester gas system improvements including, but not limited to, new digester pressure relief and vacuum valves, foam separator, moisture and sediment trap, gas flow meter, isolation valves and piping associated with the new digester.
   d. Construct a new access bridge from the DC2 control building to the new digester.
   e. Modify the existing DC2 digesters, including, but not limited to, adding fall protection tie off anchors at roof access hatches, improving access to the digester overflow box, removal of existing overflow isolation slide gates, piping modifications and installation of four Owner furnished knife gate valves, and installation of new digester gas isolation valves.
   f. Construct improvements to the Digester Complex 1 (DC1) flare including, but not limited to, a new modulating waste gas burner (WGB) bypass valve, new regulator, new WGB electronic controller, new spark generator and panel, a new uninterruptible power supply, and new exposed and buried digester gas piping.
   g. Modify the existing DC1 sludge piping, adding new piping and valves.
   h. Install and commission new actuated valves for digester feed to DC1 and DC2 in the basement of the Solids Building.

i. Install and commission a new FOG feed train to the new digester including a dedicated progressive cavity feed pump, flow meter, control valve, and piping from the Brown Grease Receiving Facility.
j. Install and commission two new high-efficiency, non-condensing natural gas boilers, boiler loop pumps, and associated hot water system pumping, valves, and piping modifications.
k. Replace the primary heat loop pumps in DC 2, the secondary heat loop pumps in the Brown Grease Receiving Facility, and make associated piping, valves, and instrumentation.
l. Modify the heating water recirculation instrumentation in DC 1 basement.
m. Install and commission a new hot water recirculation pump for the FOG offloading screen non-potable water hot water system.
n. Demolish the existing DC 2 electrical room air handling unit and condenser. Install and commission a new air handling unit and condenser and upsize the supply and return ductwork.
o. Site improvements including, but not limited to, yard piping, a new decant facility, site lighting, drainage improvements, irrigation sleeves, topsoil and compost, asphalt roadways and curb and gutter improvements.
p. New motor control center, electrical panelboards, transformers, instrumentation, and associated conduits and conductors.
q. Upgrades to the existing electrical, instrumentation and SCADA systems necessary (equipment replacement or improvements) to support the modifications.
r. Furnish and install related equipment, temporary items and systems, and other appurtenances necessary to complete the Work and to provide a complete and functional system in accordance with the Contract Documents.

B. The Work also includes furnishing and installing related equipment, temporary items, and other appurtenances necessary to complete the Work and to provide a complete and functional system in accordance with the Contract Documents.

C. The Work is located at the Durham Advanced Wastewater Treatment Facility, 16580 S.W. 85th Avenue, Tigard, OR 97224.

1.03 OTHER WORK AT THE SITE

A. Other Work or Adjacent Work at Site to be coordinated per General Condition Article 8 Other Work at the Site. The following list includes, but not limited to, the additional Work occurring at the Site:

1. Durham Water Resource Recovery Facility Odor Control Phase 3 Headworks project.

1.04 WORK SEQUENCE

A. Contractor’s attention is directed to Section 01140, Work Restrictions, for detailed information on the Work sequence restrictions.

B. Contractor shall sequence Work and Site access so that it will not interfere with wastewater treatment operations. The facility must remain in service at all times.

C. Contractor shall schedule all Work with Owner’s personnel to minimize interference with operating the facility.

1.05 CONTRACTOR USE OF SITE

A. Contractor’s use of the Site shall be limited to its construction operations, including onsite storage of materials, onsite fabrication facilities, and field offices.

B. Contractor access points, staging and parking areas have been designated on the Drawings. Contractor shall restrict its operations to those areas and where the Contract Work shall be performed.

C. Contractor is advised that all indoor areas (buildings and galleries) are nonsmoking areas.

1.06 OWNER USE OF THE SITE

A. Owner will utilize the Site during the entire period of construction to conduct Owner’s normal operations.

1.07 PROJECT MEETINGS

A. Preconstruction Conference:

1. Prior to commencing Work at the Site, a preconstruction conference will be held at Owner’s office at a mutually agreed time, but no later than 14 days after the Notice to Proceed. The conference shall be attended by the Contractor's Project Manager, Superintendent, Quality Control

Engineer, Safety Representative, and Subcontractors. Subcontractor attendance shall be requested and approved by Engineer. Other attendees will be:

a. Engineer and the Resident Project Representative.
b. Representatives of Owner.
c. Governmental representatives, as appropriate.
d. Utilities representatives, as appropriate.
e. Others as requested by Contractor and Owner upon approval by the Engineer.

2. Contractor shall bring the preconstruction conference submittals in accordance with Section 01330, Submittal Procedures.
3. The purpose of the conference is to designate responsible personnel and establish a working relationship. Matters requiring coordination will be discussed and procedures for handling such matters established. The complete agenda will be furnished to Contractor prior to the meeting date.
4. Contractor should be prepared to discuss all of the items listed below.
   a. Contractor's initial Project Schedule that highlights key Work Restrictions and Work Sequence items.
   b. Major equipment deliveries and storage plan.
   c. Shop Drawing, Samples, and Other Submittals schedule per Section 01330, Submittal Procedures.
   d. Submittal procedure for Submittal of Shop Drawing, Samples, and Other Submittals.
   e. Processing applications for payment.
   f. Maintaining record documents procedure.
   g. Permit Inspection and Special inspection coordination procedures.
   h. Field decisions and Change Orders procedures.
   i. Use of Site, office, storage areas, and housekeeping.
   j. Site security procedures.
   k. Emergency alarm procedures.
   l. Emergency assembly areas and emergency personnel direction.
   m. Deactivation Request procedures.
   n. Daily reporting of construction activities procedure.
   o. Temporary utilities.
   p. Designation of Contractors Authorized Representatives and contact information:
      1) Project Principal.
      2) Project Manager.
      3) Superintendent.
      4) Subcontractor superintendent representatives.
5. Engineer will preside at the preconstruction conference and will arrange for keeping and distributing the minutes to all persons in attendance. Contractor shall advise Engineer within 5 days of receipt of the minutes if Contractor does not agree with the content of the minutes.

6. Contractor and its subcontractors should plan on the conference taking 4 hours. The conference will include reviewing the Drawings and Specifications with Engineer and Owner.

B. Progress Meetings:

1. Engineer will schedule and hold regular onsite progress meetings at least weekly and at other times as requested by Contractor or as required by progress of the Work. Contractor and Engineer shall attend each meeting and representatives of Owner may also attend. Contractor may at its discretion request attendance by representatives of its suppliers, manufacturers, and subcontractors. Attendance by such representatives shall be subject to approval of Engineer.
2. Contractor to present the following at the progress meeting:
    a. Overall CPM schedule per Section 01324, Construction Schedule, and anticipated updates to overall CPM Schedule.
    b. Three-week look-ahead schedule as a detailed subset of the overall CPM schedule.
    c. Submittal status.
    d. Request for Information status.
    e. Change order status.
    f. Coordination with operations for facility deactivation and tie-in requests status.
    g. Permit coordination status.
    h. Issues that may impact its progress and propose solutions to resolve these issues.
    i. Payment application status.
    j. Contractor shall include additional status information requested by Engineer.
3. Engineer will preside at the progress meetings and will arrange for keeping and distributing the minutes. Contractor shall advise Engineer within five days of receipt of minutes if Contractor does not agree with the content of the minutes.
4. Engineer shall review the following:
    a. Actual start and finish dates of completed activities since the last progress meeting.
    b. Durations and progress of activities not completed.
    c. Percentage completion of items on the Application for Payment.
    d. Overall Project progress per the current CPM Construction Schedule and the potential effect on Contract Time and Contract Price.

1.08 PRE-INSTALLATION MEETINGS

A. Contractor shall provide pre-installation coordination meetings for Work elements that require specialized equipment, suppliers, manufacturers, and installers to ensure successful integration into the Project.

B. Pre-installation/pre-submittal meetings coordination meetings include:

a. Construction Noise Mitigation Plan.
b. Electrical, Instrumentation, and Controls Pre-submittal Conference.
1) Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
c. Concrete Ready Mix Design.
d. Dewatering Plan.
e. Excavation and Shoring Plan.
f. Concrete Embedded Liner Installation.
g. Vertical Mixer Installation.
h. Primary and Secondary Hot Water Loop Replacement Plan.
i. Digester Gas Piping Deactivation Plan.
j. Waste Gas Burner 1 Deactivation Plan.

C. Contractor shall distribute to each anticipated participant a written notice and agenda for each meeting at least 4 days before the meeting.

D. Contractor shall schedule the pre-installation meeting per the specification requirements or at least 21 days in advance of installation.

E. Contractors shall conduct meetings in Engineer’s field office or other mutually agreed upon place.

F. Contractor shall require attendance of the Superintendent and all appropriate manufacturers, suppliers, installers, and subcontractors.

G. Contractor shall invite Owner and Engineer.

H. Engineer to preside at meetings.

I. Engineer to record minutes of meeting and distribute copies of minutes to participants and interested parties.

1.09 POST CONSTRUCTION MEETING

A. Contractor shall meet with Owner and Engineer and inspect the Work 11 months after the date of Substantial Completion.

B. Owner shall arrange the meeting at least 7 days before meeting.

C. Contractor shall meet in Owner's office or other mutually agreed upon place.

D. Contractor shall inspect the Work with Owner and Engineer and draft a list of items to be completed or corrected.

E. Contractor shall review the service and maintenance contracts with Owner and Engineer, and take appropriate corrective action when necessary.

F. Contractor shall complete or correct defective work and extend the correction period accordingly per General Conditions 15.08 Correction Period.

G. Contractor shall require attendance of Superintendent, appropriate manufacturers and installers of major units of constructions, and affected subcontractors.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01140
WORK RESTRICTIONS

PART 1 GENERAL

1.01 THE REQUIREMENT

A. Work shall be scheduled, sequenced, and performed in a manner which minimizes disruption to the public and the operation and maintenance of existing facilities.

B. The Contractor shall incorporate the construction and schedule constraints of this section in preparing the construction schedules required under Section 01324, Construction Schedule.

1.02 EXISTING TREATMENT PLANT

A. The Work shall be executed while all existing wastewater treatment facilities and pump stations are in operation.

B. Operation of the existing facility shall not be jeopardized nor shall the efficiency or volume of wastewater conveyance be reduced as a result of the execution of the Work. Impairing the operational capabilities of the treatment plant will result in serious environmental damage and monetary fines.

C. Conduct Work in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of wastewater to the water quality limitations specified in the discharge permit. The status of the treatment plant shall be defined as “operational” when it is capable of treating the entire quantity of wastewater received to the water quality limits specified in the discharge permit.

D. The construction sequence and constraints in this section do not include all items affecting the completion of the Work, but are intended to describe the sequence of critical events and associated constraints necessary to minimize disruption to the ongoing treatment plant processes and to ensure compliance with NPDES Permit requirements and prevent all overflows within the collection system.

E. The Work Restrictions described are not all inclusive and additional items of Work not included or described may be required to minimize disruption and ensure operational compliance. Deviation from or modification of these suggested sequences is permitted if techniques and methods known to the Contractor will result in reducing disruption to the facility operation and

maintaining treatment efficiency, avoiding violation of scheduling constraints, and if deviation is approved in advance by the Engineer and Owner's Representative.

1.03 OPERATION OF PLANT EQUIPMENT

A. Operational functions, deactivations, or shutdown of existing treatment plant processes or equipment required to facilitate Contractor's Work will be done by the Owner's personnel only.

B. The plant operation and maintenance personnel will cooperate as is practical in order to facilitate Contractor's Work. However, certain shutdown and connections may only be permissible at times other than normal working hours such as nights or weekends. No additional payment will be made to the Contractor for any night, weekend, or holiday premium or overtime payments.

C. If it becomes necessary for the proper operation or maintenance of portions of the plant, the Owner may require the Contractor to reschedule an approved shutdown. If notice of said rescheduling is given to the Contractor at least 24 hours in advance of the scheduled shutdown, the Contractor shall not be entitled to additional compensation due to the impacts of rescheduling. The Contractor shall then reschedule its Work so there shall be no conflict with necessary operations or maintenance of the plant. The Contractor shall, within 2 working days, furnish the Owner's Representative a revised Deactivation Request and a plan for rescheduling the shutdown in accordance with the requirements of the construction schedule.

1.04 DEACTIVATION REQUESTS

A. The Contractor shall not remove from service, operate any equipment, tie-in, de-energize, and or modify operational settings for any facility without permission from the Owner's Project Representative.

B. Modifications to existing facilities, the construction of new facilities, and the connection of new to existing facilities may require the temporary outage or bypass of existing treatment processes or facilities. In such cases, the Contractor shall coordinate Work with the Owner's Representative as described below. The Contractor shall submit a detailed Deactivation Plan and time schedule for all Work activities to accomplish modification.

C. Deactivation Plans shall be submitted to the Owner's Representative for approval a minimum of 14 days in advance of the time that such deactivations are required. The Deactivation Plan shall be coordinated with the construction schedule and shall meet the Work Restrictions. The Deactivation Plan shall describe the Contractor's method of bypassing any deactivated unit and for preventing bypassing of other treatment units; the length of time required to

complete the operation; any necessary temporary power, controls, instrumentation, or alarms required to maintain control, monitoring, and alarms for the associated facilities; and the manpower, plant, and equipment which the Contractor shall provide in order to ensure proper operation of associated treatment units. All costs for preparing and implementing the Deactivation Plans shall be the responsibility of the Contractor as part of the Work.

D. The Contractor shall not begin an alteration affecting existing facilities until specific written approval has been granted by the Owner's Representative in each case.

E. The Owner's Representative will coordinate the Contractor's planned procedure with Owner personnel. The Owner's Representative have the authority to modify any proposed shutdown procedures if such procedures would adversely impact the plant operations.

F. The Owner's Representative shall be notified in writing a minimum of 7 days in advance of the required deactivation if the schedule for performing the Work has changed or if revisions to the Deactivation Plan are required. The Contractor shall provide written confirmation of the deactivation date and time 2 days prior to the actual deactivation. This notification shall also provide confirmation that the Contractor has all the required parts, materials, tools, and equipment on-hand to successfully undertake and complete the deactivation.

1.05 BYPASS FACILITIES

A. Bypassing of untreated or partially treated sewage to surface waters or drainage courses is strictly prohibited during construction. In the event accidental bypassing is caused by the Contractor's operations, the Owner shall immediately be entitled to employ others to stop the bypassing and costs incurred there from, including any regulatory agency fines resulting there from, will be deducted from the Contractor's construction progress payments. If accidental bypass occurs, the Contractor shall immediately inform the Owner's Representative.

B. Install and maintain bypass facilities, including pumping, and temporary components required to keep facility operations online.

C. Bypass pumping control must mimic typical plant flow and must be capable of evenly splitting flow and controlling flow rate based on process requirements.

D. Bypass pumping redundancy, installed or standby, must be provided and approved by Engineer and Owner prior to use.

E. Conditions that require bypass facilities include, but are not limited to:

1. Work sequencing activities required to complete Project.
2. Failure to meet Work Constraints identified herein.
3. Inclement weather during temporary shutdowns that require increased treatment or containment capacity.

1.06 TEMPORARY CONNECTIONS

A. The making of connections to existing facilities or other operations that interfere with the operation of the existing equipment or process flow paths shall be thoroughly planned in advance, and all required equipment, materials, and labor shall be on hand at the time of undertaking the connections. Work shall be completed as quickly as possible and with as little delay as possible, and shall proceed continuously (24 hours a day and 7 days a week) if necessary to complete modifications and/or connections in the minimum time.

B. The cost of any temporary facilities and night, weekend, or holiday work and overtime payments required during process interruptions shall be included in the price of the Work.

C. Temporary facilities and piping shall be provided to minimize interference by Contractor with Owner’s operation and maintenance of the wastewater treatment plant. Unless otherwise indicated, each temporary pipeline (including sample lines) shall be of the same size as its connection to the existing or permanent facility at the downstream end of the pipeline. Piping materials shall be suitable for the material being conveyed and be as required in the Specifications. Temporary bulkheads necessary to isolate wetted process areas to perform Work shall be designed and stamped by an engineer registered in the State of Oregon.

D. When temporary electrical power, controls, instrumentation, or alarms are required for routine continuous operations of existing or new equipment, the Contractor shall provide the necessary equipment and appurtenances. Prior to installing said equipment and appurtenances, Contractor shall furnish a submittal on the proposed components and installation for Engineer’s review and approval.

E. A plan showing the size and location of the temporary facilities and piping shall be submitted to the Engineer and Owner’s Representative at the same time as the Deactivation Plan required under this section. All costs for design, provision, operation, and removal of temporary facilities and piping shall be the responsibility of the Contractor.

1.07 SCHEDULE CONSTRAINTS

A. General: It is the Contractor's responsibility to coordinate and plan the construction activities to integrate each schedule constraint into performance of the overall Work. The constraints identified herein are general descriptions of the major activities requiring sequencing or interface with the existing plant operation. It is not the intent of this section to list all sequences, constraints, or coordination items required for the Work. Coordination of the detailed Work constraints within specification sections is required.

B. Contractor shall review the requirements for start-up and testing in Section 01756, Testing and Facility Startup.

C. Process, Facility, or Service Shutdown:

1. All diversions and shutdowns to plant flows and processes shall be subject to the requirements for a deactivation request and actual process, flow, and weather conditions existing at the time of the requested deactivation. Owner's determination regarding the acceptability of proceeding with a planned diversion or shutdown shall be final.
2. Contractor shall work continuously during diversions and shutdowns (1) if necessary, (2) when specified, or (3) when requested by Owner and Engineer to complete the work within the time allotted.

D. Work Constraints:

1. The submitted Work Sequence Plan shall incorporate the following general Work Constraints regarding treatment plant operations:
    a. Contractor shall provide and maintain a temporary construction noise barrier along the west side of the Project Site for the duration of the Project.
    b. Contractor must delineate and maintain a path for plant staff and equipment (such as, maintenance carts and golf carts) to access Digester Complex 2 at all times.
    c. Contractor access to SW Waverly Drive is strictly prohibited at all times.
    d. Contractor must allow grit and screening haulers full use of and unimpeded access to the headworks during regular work hours.
    e. Contractor must allow septage haulers full use of and unimpeded access to the Septage Receiving Station at all hours.
    f. Contractor must allow haulers full used of and unimpeded access to the Brown Grease Receiving Facility at all times.
    g. Contractor shall maintain public access to the existing RV Dump Station at all times.

h. Contractor must not impede access to other construction projects occurring simultaneously, including the Odor Control Phase 3 Headworks project.
i. Design and provide all temporary piping and support systems as required to protect and maintain existing piping in service. Coordinate temporary piping and support systems with the requirements of this section.
j. Contractor shall maintain public pedestrian and bicycle access to Cook Park via 85th Avenue at all times.
k. Contractor shall provide temporary security fencing to secure the Site at all times.
l. Contractor shall provide temporary domestic hot water service for the O&M Building anytime its hydronic heating water service is interrupted. Heating capacity of the temporary domestic water heater must meet the existing domestic hot water heat exchanger capacity, 1,500,000 Btu/hr. Refer to Drawing 920-M-130 for the recommended tie-in location. Heating water outages in are expected during, but not limited to, work in the following areas:
    1) Modification of the primary-secondary heating water loop interchange, Section A, Drawing 715-M-301.
m. Contractor shall replace one Secondary Loop Heat Pump at a time, so heating water service is not interrupted unnecessarily.

2. The submitted Work Sequence Plan shall incorporate the following Work Constraints regarding treatment process and operations, and be coordinated with operations:
    a. Two of the Digester Complex 2 (DC2) digesters or one of the DC2 digesters and two Digester Complex 1 (DC1) digesters must be in operation at all times.
    b. Transfer of sludge to the new digester must occur on or after October 15, with commissioning and performance testing completed before January 30.
    c. One of the two waste gas burners located at DC1 and DC2 must be online and operational at all times.
    d. The Digester Complex 2 (DC2) overflow sump pump shall be deactivated for a maximum of 4 hours while the sludge recirculation pumps are offline.
    e. The digested sludge line/overflow (DSL/OF) yard piping tie in shall be performed during the DC2 sump bypass tie in. The DSL can be shutdown for a maximum of 1 day.
    f. Sludge recirculation can be offline for a maximum of 4 hours for digested sludge transfer piping, hot water, and heat exchanger feed tie-ins. Both sludge recirculation valves shall be replaced during the same shutdown.
    g. Replacement of digester gas isolation valves at DC1 and DC2 shall be completed in a maximum of 2 hours per isolation valve

and boilers shall be run on natural gas during the shutdown. This task shall be completed between May and September.

h. No welding or hot work is permitted in classified areas near digester waste gas burners. Pre-built pipe spools shall be used.
i. DC1 flare shall be offline for no more than 4 weeks for digester gas tie in and addition of isolation valves. This work shall be performed in the fall or winter.
j. One of the two primary heat loop pumps located in DC2 must be online and operational at all times.
k. Individual primary heat loop pump replacements shall be done during July or August, with a maximum of outage of 4 weeks.
l. Modifications to the heating water system that require an outage shall occur from June through September.
m. One of the two secondary heat loop circulation pumps located in Brown Grease Receiving facility must be online and operational at all times.
n. Modifications to the heating water system in the Brown Grease Receiving facility in order to add valves 715BV6611 and 715BV6612 that require an outage shall occur from June through September, with a maximum shutdown of 24 hours.
o. Replacement of MCCs in DC2 shall be done with a maximum shutdown of 2 hours and shall be done at the same time as the transformer connection.
p. Transformer relocation in DC2 shall be completed with a maximum shutdown of 8 hours.
q. HVAC system replacement shall be performed between September and April, with a maximum outage of 2 months. The system shall be operational by May.
r. A minimum of two site visits shall be required for hot water loop balancing in the Brown Grease Receiving facility.
s. At the Brown Grease Receiving facility, one FOG storage tank shall be isolated at a time to add tee and ball valve for the new FOG feed pump. Each FOG storage tank shall be offline for at least12 hours for the PVC cement to cure.
t. Solids Building Basement digester feed control valves shall be shut down for no more than 4 hours per valve.

3. Water from dewatering operations shall be directed to the onsite sanitary sewer system. The water shall meet a 400 mg/L TSS limit or be treated by Contractor to meet the limit. Verification of discharge locations shall be coordinated with the Owner’s Representative.
4. The Work will include connection to and working around facilities containing sewage, sludge, and hydrogen sulfide gas and other sewage gasses. The Contractor shall establish and abide by its Safety Plan, including observing confined space testing, entry and work procedures at all times. The Contractor shall also review and include pertinent

provisions of the Owner's treatment plant safety plan in its own Safety Plan with regard to working around chemicals and other conditions present at wastewater treatment plants.

5. The Contractor shall limit its work activities and traffic to the area of the Project Work and shall not enter any other plant areas without prior written permission from the Owner. The Contractor shall strictly obey all speed limits and other traffic laws at all times.

1.08 CONSTRUCTION SEQUENCING

A. Work Sequence Plan:

1. Using Work Constraints identified herein, the Contractor shall develop an independent Work Sequence Plan and is not necessarily obligated to follow the work sequencing described herein. The Work Sequence Plan shall include:
   a. Description and sequence of major construction activities that affect plant operations.
   b. Explanation of how Work Constraints and Milestones will be met.
   c. Coordination with Facility Startup, Training and Testing and Construction Schedule.

B. All construction activities shall be scheduled and sequenced to ensure continuous operation of the existing conveyance and treatment facilities. The Contractor's scheduling shall develop all construction sequencing so that the Work will not adversely impact conveyance or treatment. The Contractor shall be responsible for development of the construction sequencing. In implementing the construction sequencing, the Contractor shall maintain the existing facilities in service until new facilities are constructed and are operational to supplement the existing capacity. When new facilities are operational (as defined in Section 01756, Testing and Facility Startup, and Section 01770, Closeout Procedures) and accepted by the Owner, the existing facilities may be taken out of service upon approval by the Engineer and Owner's Representative.

C. The following general guidelines shall be used by the Contractor in planning the sequence of construction:

1. During all modification and demolition work, safe working conditions for personnel shall be maintained at all times. The foregoing includes at least proper trench excavation, the provision of temporary equipment guards, supports, warning signs, walkways, covers over openings, handrailing, lighting, traffic control measures, and protection of electrical equipment and power supply.
2. All temporary facilities shall be constructed in accordance with

applicable codes and regulations to operate safely and properly.

3. Valves to be temporarily shut off during the Work shall be coordinated with the Owner's Representative, tagged as such and shall be wired shut with a crimped lead seal and padlocked for safety in accordance with the Contractor's Safety Plan and in a manner acceptable to the Owner.
4. Electrical and mechanical equipment to be temporarily shut off during the Work shall be locked out and tagged for safety in accordance with the Contractor's Safety Plan and in a manner acceptable to the Owner.
5. Dewatering and excavation plans shall be reviewed and approved prior to the start of the Work.
6. All in-road work shall be planned with a traffic control plan that will be reviewed and approved prior to start of Work.
7. Liquids may be pumped to onsite sewer. Debris may be disposed of in Owner's dumpster located in the Headworks facility.
8. Short-duration shutdowns or deactivations of 4 hours or less of the DC2 digesters is permitted for completing work such as tie-in connections to the existing digester gas piping or electrical or PLC de-terminations or terminations.

D. Suggested Sequencing of Major Activities: This section provides a suggested sequence for major construction activities that incorporates the Work Constraints and Milestones specified. Additional and parallel activities will be required. The Contractor may utilize all or part of this suggested sequence in the submitted Work Sequence Plan to meet the required Work Constraints and Milestones. The Work Sequence Plan must provide an equivalent level of reliability, flexibility, and operating characteristics with respect to plant operations and meeting plant discharge permit requirements. The Contract Times, Liquidated Damages, and Contract Milestones are based, in part, on the suggested sequencing described herein. The Owner reserves the right to modify the Contract Times, Liquidated Damages, and Contract Milestones based on Contractor-initiated changes to the suggested sequencing at no additional cost to the Owner.

1. Mobilization and Site Preparation:
    a. Erect temporary fencing, tree protection fencing, and erosion control measures.
    b. Erect temporary construction noise barrier on the west side of the Project Site adjacent to the neighborhood.
    c. Measure water table elevation in existing north monitoring well.
    d. Abandon north monitoring well.
    e. Strip and grub area within footprint of new digester and decant facility.
    f. Construct temporary access road and laydown area south of DC2 Waste Gas Burner 2 (WGB) where the new decant facility will be located.

g. Install temporary construction power and route from the Brown Grease Receiving Facility to the Contractor staging area and project site.
h. Identify, label all irrigation control wires and temporarily remove existing irrigation controller. Provide temporary irrigation controllers (battery operated) for the remaining irrigation zones to remain in service during construction.

2. Digester 3:
   a. Relocate existing electrical conduits and provide temporary circuits for the access gate and site lighting.
   b. Isolate existing irrigation piping and demolish piping within footprint of excavation.
   c. Excavate and install shoring for new digester.
   d. Install digested sludge piping and pressure test.
   e. Prepare subgrade and place foundation material.
   f. Construct digester concrete foundation and walls.
   g. Construction digester concrete columns and roof.
   h. Perform tank water tightness test and repair any leaks.
   i. Install digester insulation and brick veneer.
   j. Extend digested sludge piping to DC2 basement.
   k. Backfill digester structure and remove or demolish shoring below grade.
   l. Pothole and expose utilities adjacent to the DC2 control building.
   m. Relocate natural gas piping and utilities.
   n. Construct digester bridge foundation.
   o. Install new bridge and access stairway to turret.
   p. Install vertical mixer.
   q. Install Digester Piping: Digester gas, non-potable water, digester feed, overflow piping, and drains.
   r. Install new conduit, wire, electrical devices, and instruments.
   s. Transfer sludge to new digester.
3. DC2 Control Building:
   a. Equipment and piping layout.
   b. Submit pipe layout drawings.
   c. Form and pour equipment pads.
   d. Install new digester sludge recirculation pumps, sludge heaters, grinders, valves and piping.
   e. Modify heating water supply and return piping of the existing sludge heat exchangers.
   f. Modify existing digested sludge piping between digesters and digested sludge pumps.
   g. Demolish unused conduits and install new conduits.
   h. Remove and replace existing air handing unit, condenser, and ductwork.
   i. Replace and relocate existing dry-type transformers.

j. Replace and relocate sump level transmitter and receptacle.
k. Install new PLC panel, network interface panel, motor control center sections, power distribution panel, heat trace contactor, intrinsically safe barrier panel.
l. Route new conduits and conductors.
m. Install new instruments and devices.
n. Startup and commission new equipment and devices.
o. Modify and shift existing monorail hoist.

4. Brown Grease Receiving Facility:
   a. Construct new FOG feed pump equipment pad.
   b. Install new FOG feed pump.
   c. Install new FOG feed suction and discharge piping, including non-potable water hot connections.
   d. Install new FOG offloading screen non-potable hot water recirculation pump.
   e. Install new conduit and wire for FOG feed pump and non-potable hot water recirculation pump.
   f. Modify heating water piping to add new balancing valves.
5. DC 1 Waste Gas Burner (WGB) and Gas Room Modifications:
   a. Isolate digester gas system, gas holder, and DC2.
   b. Purge digester gas piping.
   c. Install new digester gas piping and isolation valve to bypass WGB 1.
   d. Demolish existing digester gas train in DC1 gas room and at DC1 WGB.
   e. Install new buried digester gas piping and electrical conduit.
   f. Install new digester gas piping and gas train at DC1 WGB.
   g. Pressure test gas piping and purge.
   h. Replace WGB 1 pilot controller in existing control panel, replace spark generator panel, and natural gas piping.
   i. Refurbish waste gas burner.
   j. Re-instate digester gas piping and test DC1 WGB.
6. DC 1 and Solids Building Modifications:
   a. Remove and replace existing digester feed valves.
   b. Modify DSL 1 and 2 piping and connect to discharge of the dewatering centrifuge feed pumps.
   c. Install temperature transmitters on the existing DC1 sludge heat exchangers.
7. DC2 Digester Modifications:
   a. Isolate DC2 Digester 2 feed and digester gas.
   b. Drain and clean overflow box.
   c. Modify the concrete suspended slab over the digester overflow box.
   d. Install knife gates on overflow and emergency overflow piping.
   e. Demolish existing slide gates.

f. Isolate DC2 Digester 1 feed and digester gas.
g. Drain and clean overflow box.
h. Modify the concrete suspended slab over the digester overflow box.
i. Install knife gates on overflow and emergency overflow piping.
j. Demolish existing slide gates.
k. Route and reconnect non-potable water heat trace to new heat trace contactor – Must be complete by October 31.

8. Heating Water System Modifications:
   a. Remove and replace primary heat loop pumps. Replace pumps one at a time.
   b. Remove and replace secondary heat loop pumps. Replace pumps one at a time. The temporary hot water system shall be in place and tested to support the O&M building hot water supply prior to any outages of the secondary heating loop system.
   c. Install new boilers and loop pumps.
   d. Connect to existing heating water loop piping and natural gas.
   e. Startup and commission boilers.
   f. Perform the heating water system balancing and adjust balancing valves. Perform initial balance after replacement of primary and secondary loop pumps and a final balance once all heating water system modifications are complete.
9. Site Work:
   a. Install underground utilities, including electrical conduits, storm and sanitary drains, non-potable water, FOG feed piping, digested sludge, digester overflows, catch basins, manholes, and irrigation sleeves.
   b. Repair removed sections of irrigation piping.
   c. Install site lighting and yard hydrants.
   d. Remove all temporary access road material and debris.
   e. Construct new curbs and transitions curbs.
   f. Delineate areas to be hardscaped or landscaped. Final grade the site and prepare roads to be paved.
   g. Prepare subgrade and construct new sidewalks.
   h. Pave plant roads and decant facility.
   i. Install ecology blocks for the decant facility.
   j. Import topsoil and compost and apply to designated areas to be landscaped.
   k. Install signage.
   l. Remove erosion control measures
   m. Remove sound wall.
10. Work items that can be completed in parallel and/or independent of other elements of the Work:
    a. Natural gas for hot water boiler supply modifications.

b. New Boiler Installation: No hot water system shutdowns are needed due to existing isolation valves.
c. Sludge Heat Exchanger: No hot water system shutdowns are needed due to existing isolation valves.
d. Tie-in to digester feed. A new intertie connection is needed between the existing digester feed and Digester Sludge 1 (DSL1) piping in the basement of the DC2 control building.
e. Brown Grease Receiving facility secondary hot water loop pump replacement. Replace one pump at a time. First pump replaced must be fully commissioned and accepted before second pump is replaced. Provide temporary domestic hot water system during secondary hot water loop pump replacement.
f. Digester feed control valves replacement has no seasonal restrictions.

E. Suggested Sequencing of Filling Digester 3 for Startup: This section provides a suggested sequence for filling Digester 3. The Contractor shall coordinate with the Owner to develop a startup plan that ensures uninterrupted operation of existing digesters, minimize risk of oxygen entrainment into the biogas system, and comply with regulatory requirements. The startup plan shall meet the requirements and submitted in accordance with Section 01756, Testing and Facility Startup.

1. In Digester Complex 1 (DC1), Digested Sludge Lines 1 and 2 merge before entering Holding Tank 1. This suggested sequence accounts for a change in piping configuration carrying both lines to a piping header that allows for each to be operated independently.
2. Operational Considerations:
   a. Summer: The holding tanks at DC1 will need time to fill, also dewatering to the centrifuges will be offline. This process is anticipated to take 7-10 days and centrate rationing will be needed. Without centrate the SRF will not be able to process WASSTRIPate leading to a higher recycle of phosphorus.
   b. Winter: Typically, the holding tanks are used as emergency storage in case of freezing weather not allowing biosolids hauling. It is preferred to keep the holding tanks available December – February.
3. System Description:
   a. DC1 consists of Holding Tank 1 and two repurposed digesters (now Holding Tanks 2 and 3), each 707,000 gallons. Tanks 2 and 3 overflow passively to Tank 1.
   b. DC2 includes Digesters 1 and 2 (active, 1.3 million gallons each), and the new Digester 3 (1.3 million gallons).

c. Three pipelines connect the two complexes:
   1) Digester Feed Line (DF): Feeds DC2 digesters from the Solids Building.
   2) DSL 1: Conveys overflow from DC2 digesters to DC1 Holding Tanks.
   3) DSL 2: Will be used to transfer digested sludge from DC1 Holding Tanks to Digester 3 at DC2.

4. Pre-Startup Procedure:
   a. Maintain feed to Digesters 1 and 2 via Digester Feed Line.
   b. Route overflows from DC2 digesters to Holding Tanks 2 and 3 until near full.
   c. Confirm passive overflow from Holding Tanks 2 and 3 to Holding Tank 1 is functioning.
5. Filling Procedure:
   a. Digester Feed continues feeding Digesters 1 and 2 with interconnection with DSL1 isolated in upper basement of Solids Building and at DC2.
   b. Overflow from DC2 switches from DSL2 to DSL 1 to Holding Tanks 2 and 3.
   c. Use Dewatering Centrifuge Feed Pump to fill Digester 3 via DSL 2.
   d. Initial Flow: 420 GPM, tapering to 320 GPM.
   e. Fill Volume: 1,300,000 gallons (52 hours to 65 hours).
   f. Upon reaching 15 feet turn on Digester 3 mixer and heating system.
   g. Upon reaching 40 feet liquid level, connect Digester 3 to gas system.
   h. Adjust feed sequence time to Digesters 1 and 2, 25 minutes Digester 3, 10 minutes. (this is a starting point the will be increased over time until equal split is achieved).

F. The Contractor shall use the interim milestones for Substantial and Final Completion as defined below and in the Contract Documents in developing its construction plan and baseline CPM schedule. These interim milestones are not all-inclusive; the Contractor shall develop and include additional construction sequencing measures as necessary to maintain operation of existing facilities and to complete the Work within the Contract time.

1. Interim Milestone 1: New digester shall be ready for functional testing with sludge starting November 15, 2027. ORT 1 and ORT 2 testing shall be complete.
2. Substantial Completion: Substantial Completion shall be the point in time when the new digester has been commissioned, successfully completed performance testing and is accepted by the owner.

3. Final Completion: All Project scope has been installed, tested and the entire punchlist is complete and accepted by Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01292
SCHEDULE OF VALUES

PART 1 GENERAL

1.01 GENERAL

A. This section defines the process whereby the Schedule of Values (lump sum price breakdown) shall be developed. Monthly progress payment amounts shall be determined, in part, from the monthly progress updates of the CPM Schedule activities.

1.02 PRELIMINARY SCHEDULE OF VALUES

A. The Contractor shall submit a preliminary Schedule of Values (SOV) for the general and major components. The draft SOV shall be provided at the Preconstruction Conference. The SOV shall include, at a minimum, the proposed list and value for all Work components. All components shall include a separate line item as indicated in Supplement Exhibit A – Example Schedule of Values. Exhibit A is the minimum requirements and may be changed, amended, added to and/or deleted from when establishing the Preliminary SOV.

B. The Contractor and Owner/Engineer shall meet and jointly review the Schedule of Values and make any adjustments, in the opinion of the Owner and/or Engineer, these are necessary to establish fair and reasonable allocation of values for the major Work components. Front-end loading will not be permitted. The Owner or Engineer may require reallocation of major Work components from items in the above listing if in the opinion of the Owner or Engineer such reallocation is necessary.

1.03 FINAL SCHEDULE OF VALUES

A. The Contractor shall prepare and submit a final Schedule of Values to the Owner and/or Engineer within 30 days from the date of Notice to Proceed. The detailed Schedule of Values shall be the final agreed upon line items and values for all general and major work items. The Owner and/or Engineer shall be the sole judge of acceptable numbers, details and description of values established. The Exhibit A – Example Schedule of Values is the minimum requirements. The number and detail of descriptions shall be determined by the Owner and/or Engineer. Once finalized the schedule of values will be added to the Electronic Construction Management Software system.

1.04 ESTIMATED PROGRESS PAYMENTS

A. Within 15 days after Engineer's acceptance of the Detailed Schedule of Values and the Original CPM Construction Schedule as per Section 01324, Construction Schedule, Article CPM Schedule Submittals Paragraph Revisions to the Original CPM Schedule, the Contractor shall provide the Engineer with an estimate of anticipated Progress Payments, by month, throughout the Project's construction duration.

1.05 CHANGES TO SCHEDULE OF VALUES

A. In the event that the Contractor and Engineer agree to make adjustments to the original Schedule of Values because of inequities discovered in the original accepted detailed Schedule of Values, increases and equal decreases to values for activities may be made.

B. Approved change orders reflected in the CPM Schedule shall be incorporated into the Schedule of Values as a single unit identified by the change order number.

1.06 COMPLETE AND TIMELY SUBMISSIONS

A. The Schedule of Values information is an integral part of the progress payment information. As such, it is critical information for evaluating the Project's progress. Accordingly, if any submittal required by this section is found to be incomplete or is submitted later than required, it may result in a deferral by Engineer to recommend all or any part of Contractor's Application for Payment, either partial or final.

1.07 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Exhibit A – Example Schedule of Values.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

EXHIBIT A – EXAMPLE SCHEDULE OF VALUES

PROCESS	DESCRIPTION	AMOUNT	BILLED TO DATE	AMOUNT REMAINING	NOTES
1 - GENERAL					
1	Mobilization	-	-	-	Max 1% of Contract
2	Bonds and Insurance	-	-	-	
3	Demobilization	-	-	-	Max 2% of Contract
4	Project Management	-	-	-	
5	Temporary Utilities	-	-	-	
6	Erosion Control				
7	Permits	-	-	-	
8	General Conditions/CPM Schedule	-	-	-	
9	Demolition				May expand area
10	Startup and Testing	-	-	-	10% of total Electrical, Installation and Controls. Shall not be paid until successful completion of all requirements in 01756
11	Performance Testing/Closeout	-	-	-	
12	Dewatering				
13	Construction Entrance, Dust Control, Tire Wash				Pay per month
14	Shoring and Excavation Protection				
2 – EQUIPMENT OR AREA #1					
1	Mechanical Equipment	-	-	-	
2	Installation of Mechanical Equipment	-	-	-	
3	Electrical	-	-	-	
4	Instrumentation and Controls	-	-	-	
5	Component #1	-	-	-	
6	Installation of Component #1	-	-	-	
7	Slide Gates	-	-	-	
8	Installation of Slide Gates	-	-	-	
9	Motor Actuated Valves	-	-	-	
10	Installation of Motor Actuated Valves	-	-	-	
11	Instrumentation	-	-	-	
12	Subgrade Preparation	-	-	-	

EXHIBIT A – EXAMPLE SCHEDULE OF VALUES

PROCESS	DESCRIPTION	AMOUNT	BILLED TO DATE	AMOUNT REMAINING	NOTES
13	Ground Improvements	-	-	-	
14	Formwork	-	-	-	May expand for multiple pours/areas
15	Reinforcing Steel	-	-	-	May expand for multiple pours/areas
16	Placement of Concrete	-	-	-	May expand for multiple pours/areas
17	Metal Fabrications	-	-	-	
3 – EQUIPMENT OR AREA #2 ...(CONTINUE LIST BASED ON EQUIPMENT AREAS)...					
1	Mechanical Equipment	-	-	-	
2	Installation of Mechanical Equipment	-	-	-	
3	Electrical	-	-	-	
4	Instrumentation and Controls	-	-	-	
5	Component #1	-	-	-	
6	Installation of Component #1	-	-	-	
7	Slide Gates	-	-	-	
8	Installation of Slide Gates	-	-	-	
9	Motor Actuated Valves	-	-	-	
10	Installation of Motor Actuated Valves	-	-	-	
11	Instrumentation	-	-	-	
12	Subgrade Preparation	-	-	-	
13	Ground Improvements	-	-	-	
14	Formwork	-	-	-	May expand for multiple pours/areas
15	Reinforcing Steel	-	-	-	May expand for multiple pours/areas
16	Placement of Concrete	-	-	-	May expand for multiple pours/areas
17	Metal Fabrications	-	-	-	
4 – SITE CIVIL					
1	Major Pipe #1	-	-	-	
2	Major Pipe #1 Installation	-	-	-	
3	Major Pipe #2 Relocation	-	-	-	
4	Major Pipe #2	-	-	-	

EXHIBIT A – EXAMPLE SCHEDULE OF VALUES

PROCESS	DESCRIPTION	AMOUNT	BILLED TO DATE	AMOUNT REMAINING	NOTES
5	Major Pipe #2 Installation	-	-	-	
6	Major Pipe #3	-	-	-	
7	Major Pipe #3 Installation	-	-	-	
8	Manholes	-	-	-	
9	Manhole Installation	-	-	-	
10	Electrical Handholds				
11	Electrical Handhold Installation	-	-	-	
12	Ductbank	-	-	-	
13	Ductbank Installation	-	-	-	
14	Miscellaneous Small Pipe/Conduits	-	-	-	
15	Miscellaneous Small Pipe/Conduits Installation	-	-	-	
16	Grading	-	-	-	
17	Paving	-	-	-	
18	Sidewalks	-	-	-	
19	Gravel Surfaces				
20	Site Lighting	-	-	-	
21	Storm Drain Pipe	-	-	-	
22	Storm Drain Pipe Installation	-	-	-	
23	Import Suitable Backfill	-	-	-	
24	Export Unsuitables	-	-	-	

SECTION 01320
WEB-BASED CONSTRUCTION MANAGEMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. The Owner and Contractor shall utilize Procore Technology, Inc's Construction Operating System (Construction OS) web-based system for electronic submittal of all data and documents throughout the duration of the Contract. Construction OS is a web-based electronic media site that is hosted by PROCORE utilizing their Construction OS web solution. Construction OS will be made available to all Contractors' Project personnel, subcontractor personnel, suppliers, consultants and the Designer of Record. The joint use of this system is to facilitate; electronic exchange of information, automation of key processes, and overall management of the contract. Construction OS Project Management utility shall be the primary means of Project information submission and management. When required by the Owners representative, paper documents will also be provided. In the event of discrepancy between the electronic version and paper documents, the paper documents will govern. Construction OS is a registered trademark of Procore Technology, Inc.

1.02 USER ACCESS LIMITATIONS

A. The Owners representative will control the Contractor's access to Construction OS by allowing access and assigning user profiles to accepted Contractor personnel. User profiles will define levels of access into the system; determine assigned function-based authorizations (determines what can be seen) and user privileges (determines what they can do). Sub-contractors and suppliers will be given access to Construction OS through the Contractor. Entry of information exchanged and transferred between the Contractor and its sub-contractors and suppliers on Construction OS shall be the responsibility of the Contractor.

B. Joint Ownership of Data: Data entered in a collaborative mode (entered with the intent to share as determined by permissions and workflows within the Construction OS system) by the Owners Representative and the Contractor will be jointly owned.

C. Data Access after Project Completion: All Project participants can request a copy of their Project information from Construction OS upon completion of the Project. Participants are responsible for fees related to Construction OS, preparing and shipping the data archive. To request an archive complete a support request in the Construction OS application. The support request should include the address for shipping the archive too.

1.03 AUTOMATED SYSTEM NOTIFICATION AND AUDIT LOG TRACKING

A. Review comments made (or lack thereof) by the Owner on Contractor-submitted documentation shall not relieve the Contractor from compliance with requirements of the Contract Documents. The Contractor is responsible for managing, tracking, and documenting the Work to comply with the requirements of the Contract Documents. Owner’s acceptance via automated system notifications or audit logs extends only to the face value of the submitted documentation and does not constitute validation of the Contractor’s submitted information.

1.04 SUBMITTALS

A. See Section 01330, Submittal Procedures.

1.05 COMPUTER REQUIREMENTS

A. The Contractor shall use computer hardware and software that meets the requirements of the Construction OS system as recommended by Procore Technology, Inc. to access and utilize Construction OS. As recommendations are modified by Construction OS, the Contractor will upgrade their system(s) to meet the recommendations or better. Upgrading of the Contractor's computer systems will not be justification for a cost or time modification to the Contract. The contractor will ensure that connectivity to the Construction OS system (whether at the home office or job site) is accomplished through DSL, cable, T-1 or wireless communications systems. It is recommended a faster connection be used when uploading pictures and files into the system. Construction OS supports the current and prior two major versions of Chrome, Firefox, Internet Explorer and Safari on a rolling basis.

1.06 CONTRACTOR RESPONSIBILITY

A. The Contractor shall be responsible for the validity of their information placed in Construction OS and for the abilities of their personnel. Accepted users shall be knowledgeable in the use of computers, including Internet Browsers, email programs, cad drawing applications, and Adobe Portable Document Format (PDF) document distribution program. The Contractor shall utilize the existing forms in Construction OS to the maximum extent possible. If a form does not exist in Construction OS the Contractor must include a form of their own or provided by the Owner representative as an attachment to a submittal. Adobe PDF documents will be created through electronic conversion rather than optically scanned whenever possible. The Contractor is responsible for the training of their personnel in the use of Construction OS (outside what is provided by the owner) and the other programs indicated above as needed.

1. User Access Administration: Provide a list of Contractor's key Construction OS personnel for the Owner’s Representative acceptance. Contractor is responsible for adding and removing users from the system. The Owners Representative reserves the right to perform a security check on all potential users. The Contractor will be allowed to add additional personnel and subcontractors to Construction OS.

1.07 CONNECTIVITY PROBLEMS

A. Construction OS is a web-based environment and therefore subject to the inherent speed and connectivity problems of the Internet. The Contractor is responsible for its own connectivity to the Internet. Construction OS response time is dependent on the Contractor’s equipment, including processor speed, Internet access speed, etc. and current traffic on the Internet. The Owner will not be liable for any delays associated from the usage of Construction OS including, but not limited to, slow response time, down time periods, connectivity problems, or loss of information. The contractor will ensure that connectivity to the Construction OS system (whether at the home office or job site) is accomplished through DSL, cable, T-1 or wireless communications systems. It is recommended a faster connection be used when uploading pictures and files into the system. Under no circumstances shall the usage of the Construction OS be grounds for a time extension or cost adjustment to the Contract.

1.08 TRAINING

A. The Owner has arranged for a 2-hour training session. The Contractor will coordinate the training time. Training will be open to all appropriate Contractor, and Engineer personnel.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. Construction OS project management application (no equal). Provided by Procore Technology, Inc., www.procore.com.

PART 3 EXECUTION

3.01 CONSTRUCTION OS UTILIZATION

A. Construction OS shall be utilized in connection with submittal preparation and information management required by sections:

1. Section 01110, Summary of Work.
2. Section 01140, Work Restrictions.
3. Section 01330, Submittal Procedures.
4. Other Division 01 sections.
5. Requirements of this section are in addition to requirements of all other sections of the specifications.

B. Design Document Submittals: All design drawings and specifications shall be submitted as CAD .dwg files or PDF attachments to the Construction OS submittal workflow process and form.

C. Shop Drawings:

1. Shop Drawing and design data documents shall be submitted as cad.dwg files or PDF attachments to the Construction OS submittal workflow process and form. Examples of Shop Drawings include, but are not limited to:
   a. Standard manufacturer installation drawings.
   b. Drawings prepared to illustrate portions of the work designed or developed by the Contractor.

D. Product Data:

1. Product catalog data and manufacturers instructions shall be submitted as PDF attachments to the Construction OS submittal workflow process and form. Examples of product data include, but are not limited to:
   a. Manufacturer's printed literature.
   b. Preprinted product specification data and installation instructions.

E. Samples:

1. Sample submittals shall be physically submitted as specified in Section 01330, Submittal Procedures. Contractor shall enter submittal data information into Construction OS with a copy of the submittal form(s) attached to the sample. Examples of samples include, but are not limited to:
   a. Product finishes and color selection samples.
   b. Product finishes and color verification samples.
   c. Finish or color boards.
   d. Physical samples of materials.

F. Administrative Submittals:

1. All correspondence and pre-construction submittals shall be submitted using Construction OS. Examples of administrative submittals include, but are not limited to:
   a. Digging permits and notices for excavation.
   b. List of product substitutions
   c. List of contact personnel.
   d. Notices for roadway interruption, work outside regular hours, and utility cut overs.
   e. Requests for Information (RFI).
   f. Plans for safety, demolition, environmental protection, and similar activities.
   g. Quality Control Plan(s), Testing Plan and Log, Quality Control Reports, Production Reports, Quality Control Specialist Reports, Preparatory Phase Checklist, Initial Phase Checklist, Field Test reports, Summary reports, Rework Items List, etc.
   h. Meeting minutes for quality control meetings, progress meetings, pre-installation meetings, etc.
   i. Any general correspondence submitted.

G. Compliance Submittals Test reports, certificates, and manufacture field report submittals shall be submitted on Construction OS as PDF attachments. Examples of compliance submittals include, but are not limited to:

1. Field test reports.
2. Quality Control certifications.
3. Manufacturers documentation and certifications for quality of products and materials provided.

H. Record and Closeout Submittals:

1. Operation and maintenance data and closeout submittals shall be submitted on Construction OS as PDF documents during the approval and review stage as specified, with actual set of documents submitted for final. Examples of record submittals include, but are not limited to:
   a. Operation and Maintenance Manuals: Final documents shall be submitted as specified.
   b. As-built Drawings: Final documents shall be submitted as specified.
   c. Extra Materials, Spare Stock, etc.: Submittal forms shall indicate when actual materials are submitted.

I. Financial Submittals Schedule of Value, Pay Estimates and Change Request Proposals shall be submitted on Construction OS. Supporting material for Pay Estimates and Change Requests shall be submitted on Construction OS as PDF attachments. Examples of compliance submittals include, but are not limited to:

1. Contractors Schedule of Values.
2. Contractors Monthly Progress Payment Requests.
3. Contract Change proposals requested by the Project owner.

END OF SECTION

SECTION 01324
CONSTRUCTION SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Scheduling of the Work shall be performed by the Contractor in accordance with the requirements of this section.

B. Development of the schedule, the Project status reporting requirements of the Contract shall employ computerized Critical Path Method (CPM) scheduling. Where submittals are required hereunder, the Contractor shall submit four copies of each submittal item.

1.02 INITIAL SCHEDULE SUBMITTALS

A. The Contractor shall submit two short-term schedule documents at the Preconstruction Conference which shall serve as the Contractor's Plan of Operation for the initial 60-day period of the Contract Time and to identify the manner in which the Contractor intends to complete all Work within the Contract Time.

1. 60-Day Plan of Operation: During the initial 60 days of the Contract Time, the Contractor shall conduct operations in accordance with a 60 day bar chart type plan of operation. The bar chart so prepared shall show the accomplishment of the Contractor's early activities (mobilization, permits, submittals necessary for early material and equipment procurement, submittals necessary for long-lead equipment procurement, CPM submittals, initial Site work and other submittals and activities required in the first 60 days). Refer to Section 01140, Work Restrictions, for milestones and submittals required within the first 60 days.
2. Project Overview Bar Chart: The overview bar chart shall indicate the major components of the Work and the sequence relations between major components and subdivisions of major components. The overview bar chart shall indicate the relationships and time frames in which the various components of the Work will be made substantially complete and placed into service in order to meet the Project milestones. Sufficient detail shall be included for the identification of subdivisions of major components into such activities as (1) site work, (2) completion of all structural concrete, (3) major mechanical work, (4) equipment procurement, (5) equipment installation, (6) major electrical work, (7) instrumentation and control work, (8) time requirements for start-up and testing from Section 17050, Basic

Measurement and Control Instrumentation Materials and Methods, and (9) other important work within the overall Project scope. Planned durations and start dates shall be indicated for each work item subdivision. Each major component and subdivision component shall be accurately plotted on time scale sheets not to exceed 36 inches by 60 inches in size. Not more than four sheets shall be employed to represent this overview information.

B. The Engineer and the Contractor shall meet to review and discuss the 60-day plan of operation and Project overview Gantt chart within 5 days after submittal to the Engineer. The Engineer's review and comment on the schedules will be limited to conformance with the sequencing and milestone requirements in the Contract Documents. The Contractor shall make corrections to the schedules necessary to comply with the requirements and shall adjust the schedules to incorporate any missing information requested by the Engineer.

1.03 CPM SCHEDULE SUBMITTALS

A. Original CPM Schedule Submittal: Within 30 days after the commencement date stated in the Notice to Proceed, the Contractor shall submit for review by the Engineer a hard copy of the CPM Schedule and appropriate schedule logic information. The Contractor shall also submit an electronic copy of all the schedule submittal information. The electronic version shall be compatible with Microsoft Project 2013 to generate network diagrams and schedule reports identical to the hard copies submitted. This submittal shall have already been reviewed and approved by the Contractor's Project Manager, Project Superintendent, and the Project Estimator prior to submission. The CPM Schedule shall be a time-scaled network diagram of the "i-j" activity-on-arrow or precedence type. The Network Diagram shall describe the activities to be accomplished and their logical relationships and show the critical path.

B. The Computerized Schedule Report tabulations shall include the following:

1. Report of activities sorted by activity number. Activity numbers, where practical, shall correlate to the area numbers, if so designated on the Drawings.
2. Report of activities sorted by early start date.
3. Report of activities sorted by total float.
4. A successor-predecessor report which shall identify the successor and predecessor activities for each activity and ties between schedule activities.

C. Original CPM Schedule Review Meeting:

1. The Contractor shall, within 40 days from the commencement date stated in the Notice to Proceed, meet with the Engineer to review the original CPM schedule submittal. The Contractor shall have the Project Manager, Project Superintendent, and the Project Scheduler in attendance. The Engineer's review will be limited to the conformance to the Contract Documents. However, the review may also include:
   a. Clarifications of the design intent, process, and startup requirements.
   b. Directions to include activities and information missing from the submittal.
   c. Requests to the Contractor to clarify the schedule.

D. Revisions to the Original CPM Schedule: Within 50 days after the commencement date stated in the Notice to Proceed, the Contractor shall have revised the original CPM schedule submittal to address all review comments from the original CPM schedule review meeting and resubmit the network diagrams and reports for the Engineer's review. The Engineer, within 10 days from the date that the Contractor submitted the revised schedule will either (1) accept the schedule as submitted, or (2) advise the Contractor in writing to review any part or parts of the schedule which either do not meet the Contract requirements or are unsatisfactory for the Engineer to monitor the Project's progress and status. The Engineer may accept the schedule with conditions that the first monthly CPM schedule update be revised to correct deficiencies identified. When the schedule is accepted, it shall be considered as the "Original CPM Construction Schedule" until an updated schedule has been submitted. The Owner reserves the right to require that the Contractor adjust, add to, or clarify any portion of the schedule which may later be discovered to be insufficient for the monitoring of the Work. No additional compensation will be provided for such adjustments, additions, or clarifications.

E. Acceptance:

1. Acceptance of the Contractor's schedule by the Engineer and Owner will be based solely upon compliance with the requirements. By way of the Contractor assigning activity durations and proposing the sequence of the Work, the Contractor agrees to utilize sufficient and necessary management and other resources to perform the work in accordance with the schedule. Upon submittal of a schedule update, the updated schedule shall be considered the "current" Project schedule.
2. Submission of the Contractor's progress schedule to the Owner or Engineer shall not relieve the Contractor of total responsibility for scheduling, sequencing, and pursuing the Work to comply with the

requirements of the Contract Documents, including adverse effects such as delays resulting from ill-timed Work.

F. Monthly Updates and Periodic CPM Schedule Submittals:

1. Following the acceptance of the Contractor's original CPM Schedule, the Contractor shall monitor the progress of the Work and adjust the schedule each month to reflect actual progress and any changes in planned future activities. Each schedule update submitted shall be complete including all information requested in the original schedule submittal and be in the schedule report format indicated below. Each update shall continue to show all work activities including those already completed. Completed activities shall accurately reflect "as built" information by indicating when the work was actually started and completed.
2. Neither the submission nor the updating of the Contractor's original schedule submittal nor the submission, updating, change, or revision of any other report, curve, schedule, or narrative submitted to the Engineer by the Contractor under this Contract, nor the Engineer's review or acceptance of any such report, curve, schedule, or narrative shall have the effect of amending or modifying, in any way, the Contract Times or milestone dates or of modifying or limiting, in any way, the Contractor's obligations under this Contract. Only a signed, fully executed Change Order can modify contractual obligations.
3. The monthly schedule update submittal will be reviewed monthly with the Contractor during a weekly construction progress meeting. The goal of these schedule review meetings is to enable the Contractor and the Engineer to initiate appropriate remedial action to minimize any known or foreseen delay in completion of the Work and to determine the amount of Work completed since the last month's schedule update. The status of the Work will be determined by the percent complete of each activity in the updated CPM Schedule. These meetings are considered a critical component of the overall monthly schedule update submittal, and the Contractor shall have appropriate personnel attend. As a minimum, these meetings shall be attended by the Contractor's Project Manager and Project Superintendent. Within 7 working days after the monthly schedule review meeting, the Contractor shall submit the revised CPM Schedule, the revised CPM computerized tabulations as noted in this section, the revised successor/predecessor report, the Project Status Reports as defined below and the Contractor's Application for Payment. Within 5 working days of receipt of the revised submittals, the Engineer will either accept or reject the monthly schedule update submittal. If rejected, the update shall be corrected and resubmitted by the Contractor before the Application for Payment for the update period will be processed.

G. Schedule Revisions: The Contractor shall highlight or otherwise identify all changes to the schedule logic or activity durations made from the previous schedule. The Contractor shall modify any portions of the CPM schedule which become infeasible because of activities behind schedule or for any other valid reason.

H. The Contractor shall include plan and actual progress for each task.

I. Three-Week Look-Ahead Schedule Submittals: Each week, the Contractor shall submit a schedule of planned activities and progress detailing activities for the 3-week period following the date of the weekly submission to the Engineer.

1.04 CHANGE ORDERS AND WORK CHANGE DIRECTIVES

A. Upon approval of a Change Order, or upon receipt by the Contractor of a signed Work Change Directive or other authorization to proceed with additional work, the change shall be reflected in the next submittal of the CPM Schedule. The Contractor shall utilize a sub-network in the schedule depicting the changed work and its effect on other activities. This sub-network shall be tied to the main network with appropriate logic so that a true analysis of the critical path can be made.

1.05 CPM STANDARDS

A. Definitions: CPM, as required by this section, shall be interpreted to be generally as outlined in the Association of General Contractors (AGC) publication, “The Use of CPM in Construction.” except that either “i-j” arrow diagrams or precedence diagramming format may be utilized. In the case of conflicts between this specification and the AGC document, this specification shall govern.

B. Construction Schedules: Construction schedules shall include a graphic network diagram and computerized construction schedule reports as required below for status reporting.

C. Networks: The CPM network shall be in a form of a time scaled “i-j” activity-on-arrow or precedence type diagram and may be divided into a number of separate sheets with suitable match lines relating the interface points among the sheets. Individual sheets shall not exceed 24 inches by 36 inches.

D. Construction and procurement activities shall be presented in a time-scaled format with a calendar timeline along the entire sheet length. Each activity arrow or node shall be plotted so that the beginning and completion dates of each activity are accurately represented along the calendar timeline. All activities shall use symbols that clearly distinguish between critical path

activities, noncritical activities, and free float for each noncritical activity. All activity items shall be identified by their respective activity number, responsibility code, and work duration. All noncritical path activities shall show total float time in scale form by utilizing a dotted line or some other graphical means.

E. Duration Estimates: The duration estimate for each activity shall be computed in working days and shall represent the single best estimate considering the scope of the work and resources planned for the activity. Except for certain nonlabor activities, such as curing of concrete or delivery of materials, activity duration shall not exceed 10 working days nor be less than 1 working day unless otherwise accepted by the Engineer.

F. Float Time:

1. Definition: Unless otherwise provided herein, float is synonymous with total float. Total float is the period of time measured by the number of working days each noncritical path activity may be delayed before it and its succeeding activities become part of the critical path. If a noncritical path activity is delayed beyond its float period, then that activity becomes part of the critical path and controls the end date of the work. Thus, delay of a noncritical path activity beyond its float period will cause delay to the Project itself.
2. Float Ownership: Neither the Owner nor the Contractor owns the float time. The Project owns the float time. As such, liability for delay of the Project completion date rests with the party actually causing delay to the Project completion date. For example, if Party A uses some, but not all of the float time and Party B later uses the remainder of the float time as well as additional time beyond the float time, Party B shall be liable for the costs associated with the time that represents a delay to the Project's completion date. Party A would not be responsible for any costs since it did not consume all of the float time and additional float time remained, therefore, the Project's completion date was unaffected.

1.06 SCHEDULE REPORT FORMAT

A. Schedule Reports:

1. Schedule Reports shall be prepared based on the CPM Schedule, and shall include the following minimum data for each activity:
   a. Activity numbers.
   b. Work Order No.
   c. Estimated activity duration.
   d. Activity description.
   e. Activity's percent completion.

f. Early start date (calendar dated).
g. Early finish date (calendar dated).
h. Late start date (calendar dated).
i. Late finish date (calendar dated).
j. Status (whether critical).
k. Total float for each activity.
l. Free float for each activity.

B. Project Information:

1. Each Schedule Report shall be prefaced with the following summary data:
   a. Project name.
   b. Contractor.
   c. Type of tabulation.
   d. Project duration.
   e. Contract Times (revised to reflect time extensions by Change Order).
   f. The commencement date stated in the Notice to Proceed.
   g. The data date and plot date of the CPM Schedule.
   h. If an update, cite the new schedule completion date.

1.07 COMPLETE AND TIMELY SUBMISSIONS

A. The CPM Construction Schedule information is an integral part of the Project scheduling and reporting. As such, it is critical information to evaluating the Project's progress and the proper planning of the Owner's and Engineer's work effort associated with this Project. Accordingly, if any submittal required by this section is found to be incomplete or is submitted later than required, it may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

1.08 NETWORK DETAILS AND GRAPHICAL OUTPUT

A. Produce a clear, legible, and accurate calendar based, time scaled, graphical network diagram. Group activities related to the same physical areas of the Work. Produce the network diagram based upon the early start of all activities.

B. Include for each activity, the description, activity number, estimated duration in working days, total float and all activity relationship lines.

C. Illustrate order and interdependence of activities and sequence in which Work is planned to be accomplished. Incorporate the basic concept of the precedence diagram network method to show how the start of one activity is dependent upon the start or completion of preceding activities and its completion restricts the start of following activities.

D. Indicate the critical path for the Project.

E. Delineate the specified Contract duration and identify the planned completion of the Work as a milestone. The time period between the planned and Contract completion dates, if any, shall be shown on the schedule as an activity identified as Project float unless a Change Order is issued pursuant to CPM Standards.

F. Identify system shutdown dates, system tie-in dates, specified interim completion or milestone dates and Contract completion date as milestones.

G. Include, in Addition to Construction Activities:

1. Submission dates and review periods for major equipment submittals, shoring submittals, and indicator pile program:
    a. Shoring Reviews: Allow 4-week review period for each shoring submittal.
    b. Pile Indicator Program (If Applicable): Allow 3-week review period for analysis of program.
2. Any activity by the Owner or the Engineer that may affect progress or required completion dates.
3. Equipment and long-lead material deliveries over 8 weeks.
4. Approvals required by regulatory agencies or other third parties.

H. Produce network diagram on 22-inch by 34-inch sheets with grid coordinate system on the border of all sheets utilizing alpha and numeric designations.

I. Identify the execution of the following, but no limited, and omitting items not applicable to the Work:

1. Mobilization.
2. All required submittals and submittal review times showing 30-calendar day duration for such activities and equal amount of time for resubmittal reviews.
3. Equipment and materials procurement/fabrication/delivery.
4. Excavation.
5. Shoring design and submission of detailed shoring submittals. Identify submission as a milestone.
6. Shoring review, shoring materials procurement, shoring installation and shoring removal.
7. Piles.
8. Backfill and compaction.
9. Dewatering.
10. Grading, subbase, base, paving, and curb and gutters.
11. Fencing and landscaping.

12. Concrete, including installation of forms and reinforcement, placement of concrete, curing, stripping, finishing and patching.
13. Tests for leakage of concrete structures intended to hold water.
14. Masonry.
15. Precast panels.
16. Metal fastenings, framing, structures, and fabrications.
17. Wood structures, finish carpentry, architectural woodwork, and plastic fabrications.
18. Waterproofing and dampproofing, insulation, roofing and flashing, and sealants.
19. Doors and windows, including hardware and glazing.
20. Finishes including coating and painting, flooring, ceiling, and wall covering.
21. Building specialties including furnishings, laboratory equipment, and toilet and bath accessories.
22. Process equipment, including identification of ordering lead time, factory testing and installation.
23. Pumps and drives, including identification of ordering lead time, factory testing and installation.
24. Conveying equipment including hoists and cranes, conveyor systems, and materials handling equipment, including identification of ordering lead time and installation.
25. Other mechanical equipment including fans and heating, ventilating, and air conditioning equipment.
26. Trenching, pipe laying, and trench backfill and compaction.
27. Piping, fittings and appurtenances, including identification of ordering and fabrication lead time, layout, installation and testing.
28. Valves, gates and operators, including identification of order lead time, installation and testing.
29. Plumbing specialties.
30. Electric transmission, service, and distribution equipment, including identification of ordering lead time, and factory testing.
31. Other electrical work including lighting, heating and cooling, and special systems, including identification of ordering lead time.
32. Instrumentation and controls, including identification of ordering lead time.
33. Preliminary testing of equipment, instrumentation and controls.
34. Final testing, including preparation time.
35. All operational testing.
36. Substantial completion. Substantial completion activity shall meet all requirements set forth in Section 00800, Supplementary Conditions.
37. Punch list work.
38. Operation and maintenance training.
39. Demobilization.

1.09 SCHEDULE OF SHOP DRAWING AND SAMPLE SUBMITTALS

A. After Preliminary Schedule has been submitted and accepted by Owner, Contractor shall submit a list of all Shop Drawings and sample submittals anticipated in first 90 calendar days after Notice to Proceed using early start dates.

B. Submittal of this preliminary list shall be a condition precedent to making of progress payments during the first 90 calendar days after Notice to Proceed.

C. After Baseline Schedule has been submitted and accepted by Owner, Contractor shall print out and submit list of all Shop Drawings and sample submittals for all Work using early start dates. This listing will contain all submittals required for the entire Work including those listed above.

D. Submittal of final list shall be a condition precedent to making of progress payments after the first 90 calendar days after Notice to Proceed.

E. These schedules shall conform to the requirements of the General Conditions.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01329
SAFETY PLAN

PART 1 GENERAL

1.01 SUMMARY

A. Requirements for Contractor's development and maintenance of a Project Specific Safety Plan.

B. Before any Work at the Site is started, Contractor shall have prepared Contractor's written Project Specific Safety Plan and make available both printed and electronic versions to all Contractors, Subcontractors, Engineering, Inspection, and Owner's staff involved in the Work.

C. Project Specific Safety Plan shall be in accordance with General Conditions Articles 7.12 Safety and Protection, 7.13 Safety Representative, 7.14 Hazard Communication Programs, 7.15 Emergencies, and including but not limited to additional hazards identified in this section.

D. A specific employee or officer will be designated by the Contractor to enforce compliance with all requirements set forth by the Oregon Health Authority and OSHA, including social distancing policies. Contractor will minimize all contact with Owner's personnel and occupied areas, and provide notice to the Owner when occupied areas will be encroached on.

E. Contractor shall require all Subcontractors to adhere to the Contractor's Project Specific Safety Plan, all applicable Safety Laws and Regulations, and Owner's Safety Programs.

1.02 SAFETY AND HEALTH REGULATIONS

A. Contractor's safety plan shall comply with all federal, state, and local safety and health regulations and laws including, but not limited to, the following:

1. Oregon Occupational Safety and Health Code of the Oregon Occupational Safety and Health Division (OR-OSHA), Oregon Administrative Rules (OAR), Chapter 437.
   a. Division 01, General Administrative Rules.
   b. Division 02, General Occupational Safety and Health Rules.
   c. Division 03, Construction.
2. Oregon Revised Statutes, ORS 654.
3. Oregon Safe Employment Act (OSEA).

1.03 CONSTRUCTION SAFETY PLAN – OWNERS SAFETY PROGRAMS

A. Prior to commencing Work at the Site, all Contractor and Subcontractor personnel shall complete the Clean Water Services Safety Orientation for Contractor Personnel. This online training will provide an overview of the facility, including review of the emergency gathering area, chemicals stored onsite, lockout/tagout, housekeeping, and other Owner specific safety requirements. Once the training is completed, sign the completion certificate and provide a copy to the Owner. The safety orientation training may be accessed at http://contractorsafety.cleanwaterservices.org/.

1.04 HAZARD REVIEW WORKSHEET

A. Owner and Engineer have determined that the following hazards are reasonably anticipated to arise during the course of the Work:

1. Confined space entry.
2. Construction zone traffic control.
3. Aerial lift operation.
4. Fall protection.
5. Excavation/trenching.
6. Control of Energy.
7. Crane operations.
8. Electrical work.
9. Work at elevation/ladders.
10. Industrial truck (forklift) hazards.
11. Heat illness.
12. Hot work permits.
13. Ladders.
14. Scaffolding.
15. Welding.
16. Waste disposal.

B. A hazard review worksheet has been included as a supplement to this section. Contractor shall provide written responses for how they plan to address each of the hazards noted above and identify any others anticipated by the Contractor. This information shall be included in their Project Specific Safety Plan.

1.05 EMERGENCY ACTION PLAN

A. Contractor shall include in their Project Specific Safety Plan, an Emergency Action Plan. The Emergency Action Plan shall address how to handle, at a minimum, the following types of incidents:

1. Medical emergencies.
2. Weather emergencies.
3. Natural disasters.
4. Heavy equipment failures.
5. Hazardous material incidents.
6. Worker injuries.
7. Cave-in rescues.
8. Fall arrest rescues.
9. Confined space rescues.
10. Fires and explosions.
11. Any other potential emergency as dictated by the Work or Site conditions.

B. The Emergency Action Plan shall note:

1. Address and description of the Project Site.
2. Emergency response numbers for the emergency services (police, fire, medical), and any specialty rescue subcontractors.
3. Name and address of nearest medical facilities.
4. Reporting procedure for emergency situations.
5. Any local alarms or procedures.
6. Procedure for accounting for all Contractor personnel in the event of an emergency.

C. The Emergency Action Plan shall be posted in a conspicuous location, where all Contractor's personnel can access it and reference it. Contractor shall keep the Emergency Action Plan up-to-date throughout the Project.

1.06 CONSTRUCTION SAFETY PLAN – OWNERS SAFETY PROGRAMS

A. Permit-Required Confined Space Entry (PRCSE) http://osha.oregon.gov/OSHAPubs/2864.pdf.

1. Project specific PRCSE spaces include, but not limited to, the following:
   a. Manholes.
   b. Open tanks.
   c. Structures above and below grade with the potential to contain wastewater.
   d. Enclosed tanks.

e. Wet wells and dry wells of pump stations.
f. Electrical vaults.

B. Factory Mutual (FM) Global - Hot Work Yellow Tag Permit Program:

1. Project specific hot work yellow tag permit activities include, but not limited to, the following:
a. Grinding.
b. Torch cutting.
c. Welding.
d. Pipe cutting.
e. Gas piping.

C. Transmit to Owner and Engineer copies of reports and other documents related to accidents or injuries encountered during construction.

1.07 STOP WORK AUTHORITY

A. All Owner's personnel shall have "stop work authority," where they may require the Contractor to immediately halt activities where there is an imminent danger to personnel or property. Such orders shall not be the basis for any claim for additional time or compensation.

B. Contractor shall ensure that the circumstances causing the stop work authority to be exercised are corrected, and that all unsafe conditions are rectified, prior to resuming work.

1.08 PANDEMIC SAFETY PLANS

A. During public health crises, such as COVID-19, Contractor shall develop project specific safety plans and procedures that address guidelines and best practices provided by the Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration (OSHA), OR-OSHA and shall be in accordance with any ordinances and executive orders set forth by the federal government, city, or state. Plans and procedures shall be communicated to employees and any other affected personnel (such as, subcontractors).

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 CONDUCT

A. Contractor and Subcontractors shall ensure that their personnel do not report to work impaired by any substance, drug, or alcohol, whether lawful or

unlawful. “Impaired” means under the influence of a substance such that the employee’s motor senses (such as: sight, hearing, balance, reaction, reflex) or judgment either are, or may be reasonably assumed to be, affected.

B. All Contractor and Subcontractor personnel shall obey all precautionary warning signs, product and process labels, and posted instructions.

C. Contractor and Subcontractor personnel shall confine their activities to the assigned work areas.

D. Derisive remarks, unsolicited comments that are sexual in nature, threatening, intimidating, coercive, or other unsafe or disruptive behavior such as fighting, and horseplay are unacceptable. Contractor shall establish rules with necessary enforcement to prevent such behavior.

E. Contractor shall perform all work in a manner that safeguards persons from injury and property from damage.

3.02 SAFETY EQUIPMENT AND SUPPLIES

A. Prior to commencing work, Contractor shall obtain all safety equipment and supplies required to complete the work and shall require Contractor’s personnel to use it where needed.

B. Owner will not provide any safety equipment or supplies.

C. Contractor shall make safety equipment and supplies available to Owner’s staff as necessary to facilitate safe access to inspect and review the Work.

D. Fire extinguishers and first aid kits shall be readily available throughout the Site.

3.03 PROHIBITED ITEMS

A. Contractor’s personnel shall not bring any of the following items onto the Site:

1. Firearms.
2. Weapons.
3. Controlled or illegal substances.
4. Alcoholic beverages.

B. Smoking, including electronic cigarettes and vaping, is prohibited inside buildings, including those under renovation or unoccupied, and within 25 feet of building entrances. Smoking shall only take place in designated areas.

3.04 NOTIFICATION TO OWNER

A. Contractor shall report all safety concerns, visits by regulatory agencies, and incidents to Owner's Project Manager.

3.05 COMPLIANCE

A. If Contractor or Subcontractor or personnel of either entity fail to adhere to the Contractor's Safety Plan submitted under this section, Safety Laws and Regulations, or the Owner's Safety Programs, Owner reserves the right to the require the Contractor to take immediate corrective action, which may include, but is not limited to:

1. Submittal of a written corrective action plan to Owner.
2. Additions or modifications to Contractor's Safety Plan, resubmittal required.
3. Removal from the Site of any Contractor or Subcontractor personnel not implementing, maintaining, or following the necessary safety and health measures to protect persons or property from damage injury, or loss.
4. Increasing the amount of Contractor or Subcontractor safety and health training.

3.06 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Oregon OSHA – Confined Spaces and Permit Spaces.
2. Facilities Management – Hot Work Permit.
3. Oregon OSHA – The ABCs of Construction Site Safety.
4. Hazard Review Worksheet.

END OF SECTION

Confined spaces and permit spaces

How to comply with *Oregon*OSHA's confined space rule 437-002-0146 for general industry and construction work

About this guide

Confined spaces are harmless as long as they are not occupied. But when workers enter a confined space to inspect equipment, fix leaks, or do construction work, they can encounter toxic gasses, corrosive chemicals, flammable solvents, or machines that start unexpectedly. If something goes wrong, a confined space can be difficult or impossible to exit. And would-be rescuers can share the fate of those they are trying to rescue.

This guide explains how to identify confined spaces and how to protect general-industry and construction workers who may need to enter them.

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Additional content available online:

- Confined space evaluation survey: Use this survey to evaluate confined spaces at your workplace. http://www.orosha.org/pdf/pubs/forms/confined_space_permit_space_survey.doc
- Sample confined space entry permits: Examples of entry permits. http://www.orosha.org/pdf/pubs/forms/entry-permit.doc
- Sample permit-space program: A written confined space program for your workplace. http://www.orosha.org/pdf/pubs/forms/permit-space-booklet.doc
- Permit space evaluation form: Use this form to identify hazards in permit spaces at your workplace. http://www.orosha.org/pdf/pubs/forms/permit-space-eval-form.doc

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About Oregon OSHA's confined space rule: 437-002-0146

Oregon OSHA's confined space rule – **437-002-0146** – protects general industry and construction industry employees who enter confined spaces that have serious or life-threatening hazards.

What 437-002-0146 requires you to do

The rule requires you to:

- Survey your workplace to identify permit spaces
- Inform employees about the location of the permit spaces and the hazards associated with those spaces
- Keep unauthorized employees out of the spaces
- Prepare a written permit-space program to protect employees who must enter a permit space
- Include a catalog of your permit spaces in your written program that describes why they are permit spaces
- Ensure that any equipment is used in accordance with the manufacturer's instructions and that your employees who use the equipment have been trained
- Ensure that employees who work around permit spaces are trained so that they understand the presence, location, and hazards associated with the spaces, and they are aware of your permit-space program
- Have an agreement with another rescue service provider if your employees will not provide rescue services

Exceptions to 437-002-0146

The rule does not apply to:

- Construction work regulated by Division 3/P Excavations, except for entry into sanitary sewer spaces that are large enough to bodily enter.
- Construction work regulated by Division 3/S Underground Construction, Caissons, Cofferdams and Compressed Air, except for sewers.
- Enclosed spaces regulated by 1910.269 in Division 2/R Electric Power Generation, Transmission and Distribution, except when that standard requires compliance with this standard.
- Enclosed spaces regulated by 1926.953 in Division 3/V Electric Power Generation, Transmission and Distribution, except when that standard requires compliance with this standard.
- Manholes and vaults regulated by 1910.268(o) in Division 2/R Telecommunications, unless the space cannot be made safe to enter even after following the requirements of 1910.268(o).
- Welding in confined spaces regulated by Division 2/Q Welding, Cutting & Brazing, when the only hazards are related to the welding process.
- Grain bins, silos, tanks, and other grain storage structures regulated by 1910.272, Grain Handling Facilities.
- Diving operations regulated by Division 2/T, Commercial Diving Operations.

Key sections of 437-002-0146

Oregon OSHA's confined space rule has 13 sections:

1. Purpose and application
2. Exceptions
3. Definitions
4. Evaluation
5. Permit-required confined space entry programs and permits
6. Permit entry
7. Equipment
8. Personnel
9. Rescue
10. Alternate entry
11. Training
12. Multi-employer worksites
13. Records

The table below shows which of the rule's key sections apply to confined spaces, permit spaces, and confined spaces that are never entered. The table also shows which sections apply if you use alternate entry procedures, have other employers enter your confined space, or if you provide rescue services.

	Key sections of Oregon OSHA's confined space rule: 437-002-0146									
	4	5	6	7	8	9	10	11	12	13
For spaces that are:	*Evaluation*	*Permit space entry programs and permits*	*Permit Entry*	*Equipment*	*Personnel*	*Rescue*	*Alternate entry*	*Training*	*Multi-employer worksites*	*Records*
■ Confined spaces	✓									
■ Permit spaces	✓	✓	✓	✓	✓	✓		✓	✓	✓
■ Never entered	✓									
If you only:										
■ Use alternate entry procedures	✓			✓			✓	✓		
■ Have other employers enter your space	✓								✓	✓
■ Are a rescue service provider		✓	✓	✓	✓	✓		✓		✓

Common questions about 437-002-0146

Q: I have a permit-space program for my facility that meets the requirements for federal OSHA's confined space rule, 1910.146, and my employees follow those requirements when they enter permit spaces. Are the requirements for 1910.146 and 437-002-0146 the same?

A: Many of the requirements are the same; however, there are also new requirements under 437-002-0146 as shown in the table below.

Similar requirements under 1910.146 and 437-002-0146	New requirements under 437-002-0146
• Definition of a confined space • Definition of a permit space • Requirement for a written program when employees enter a permit space • Roles, responsibilities, and training of entrants, attendant, and entry supervisors • Requirement that unauthorized persons do not enter a permit space • Process for entering, performing work, and exiting a permit space • Information required on the entry permit (1910.146 requires the duration of the entry; 437-002-0146 requires starting and stopping times). • Requirement for pre-planning non-entry and entry rescues • Training requirements, practice, and qualifications of rescue personnel	• Include a catalog of your permit spaces in your written program that describes why they are permit spaces. • Ensure that any equipment is used in accordance with the manufacturer's instructions and that employees who use the equipment have been trained. • Ensure that employees who work around permit spaces are trained so that they understand the presence, location, and hazards associated with the spaces, and they are aware of your permit-space program. • Have an agreement with another rescue service provider if your employees will not provide rescue services.

Q: We enter a confined space under the alternate entry procedures in 1910.146(c)(5) or reclassify the space according to 1910.146(c)(7). Are these requirements included in Oregon OSHA's confined space rule?

A: No. Oregon OSHA's confined space rule does not include these requirements. Under Oregon OSHA's rule, workers can use alternate entry procedures to enter a permit space without a permit (documentation is required to verify safe entry) and attendants, an entry supervisor, and rescue services are not required. See Page 25 in this guide for more information on alternate entry procedures.

What is a confined space?

A confined space is a space that meets all of the following conditions:

- It is large enough and so configured that an employee can fully enter the space and perform work.
- It has limited or restricted means for entry, exit, or both.
- It is not designed for continuous human occupancy.

It is large enough and so configured that an employee can fully enter the space and perform work. A space that is just large enough for a person to squeeze into, but not perform any work, is not a confined space. Similarly, a space that is too small for a person to enter completely is not a confined space.

It has limited or restricted means for entry, exit, or both. If a person must contort his or her body to enter or move around inside a space, it probably has a limited means of entry and exit. Climbing through a porthole to enter a space or crawling through a tunnel toward an exit are examples of spaces that have limited means of entry and exit.

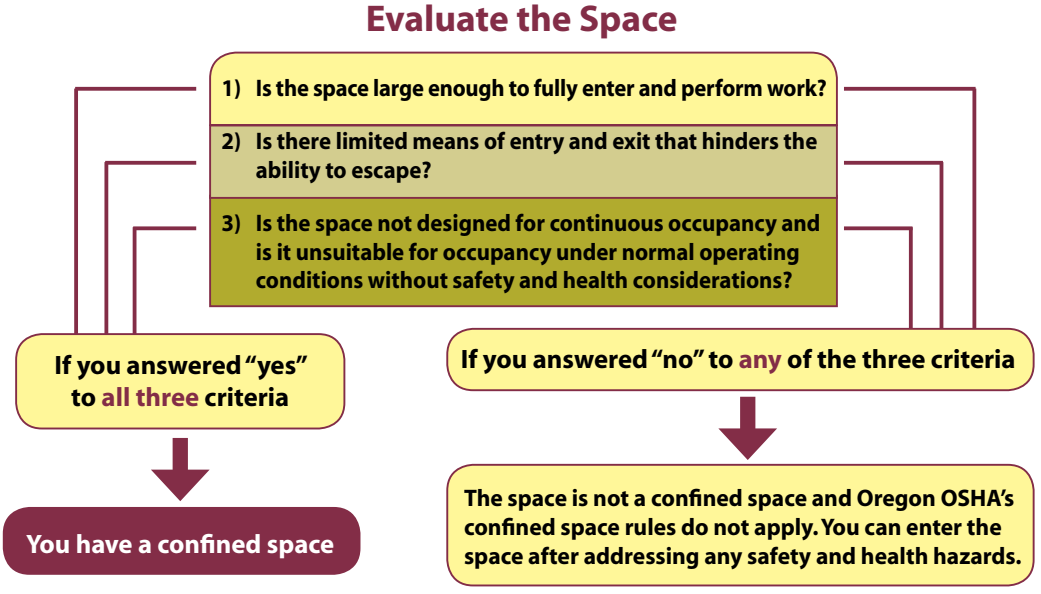
Another way of measuring limited means of entry and exit is to determine how difficult it would be to remove an injured person from the space; if there is a need for a technical rescue to remove an injured person, you probably have a limited means entry and exit. Evaluate each space on a case-by-case basis.

It is not designed for continuous human occupancy. What is the primary function and purpose of the space? A space that is designed for periodic occupancy is not the same as a space that is designed for continuous occupancy.

The presence of a fixed ladder, lighting, or ventilation does not always mean that the space was designed for continuous occupancy. Is the space designed for a person to work there or is it designed to house and protect equipment that needs to be monitored or occasionally maintained? For example, a space may have lighting for periodic occupancy that may be necessary to safely enter and exit, read gauges, or perform maintenance or repairs. Similarly, ventilation may be necessary to keep equipment from overheating or to provide fresh air for temporary job assignments or tasks. In both cases, the work performed is intermittent or temporary.

Examples of confined spaces

Confined spaces include those with depth and open tops and those with narrow openings.	
Spaces with depth and open tops	**Spaces with narrow openings**
Pits	Ship compartments
Wells	Silos
Vats	Pipes
Bins	Tunnels
Hoppers	Tanks
Degreasers	Casings
Kettles	Sewers



What is a permit space?

A permit space is a confined space that has one or more of the following characteristics:

- It has — or could have — a hazardous atmosphere.
- It contains material that could trap or bury a person.
- It is shaped so that a person could become trapped or asphyxiated.
- It has other safety or health hazards that could harm a person.

Hazards in permit spaces

Most accidents in permit spaces happen when workers and untrained rescuers do not recognize hazards in the spaces or they do not control the hazards before they enter. Never assume a permit space is safe to enter.

Permit spaces can have two types of hazards: hazardous atmospheres and physical hazards.

Hazardous atmospheres

A hazardous atmosphere affects the air in the space and can cause death or acute illness, or impair the ability of workers to escape. Hazardous atmospheres include:

- **Corrosive atmospheres.** Corrosive atmospheres accumulate from some manufacturing processes and biological or chemical reactions. Some cause immediate damage to the skin and eyes; some have no immediate effect, but cause cancer with prolonged exposure.
- **Flammable or explosive gasses, liquids, vapors, mists, fibers, or dusts.** Flammable gasses such as acetylene, butane, propane, hydrogen, and methane are common in permit spaces. Grain, nitrated fertilizers, and ground chemicals can produce combustible dusts.
- **Air or oxygen displacement.** Some substances (such as inerting gasses) can displace air or oxygen in a confined space; examples include nitrogen, helium, steam, Freon, argon, and carbon dioxide.
- **Oxygen deficiency.** Oxygen-deficient atmospheres (oxygen concentration below 19.5 percent) affect heart rate, muscle coordination, and breathing. Unprotected workers cannot survive in an oxygen-deficient atmosphere.
- **Oxygen enrichment.** Oxygen-enriched atmospheres (oxygen concentration above 23.5 percent), which can be caused by welding and from the improper use of oxygen for breathing air, increase the risk of fire or explosions.
- **Toxic dusts, mists, fumes, smoke, vapors, fibers, or gasses.** These can be released by manufacturing processes, stored materials, and work tasks. A hazardous atmosphere that poses a threat to life, would cause irreversible adverse health effects, or that would interfere with an individual's ability to escape from a confined space is called immediately dangerous to life or health (IDLH).

Some hazardous atmospheres (hydrogen fluoride gas and cadmium vapor, for example) may cause serious health effects that result 12 to 72 hours after exposure.

Air-monitoring equipment: Trained employees can use an air-monitoring meter to test for hazardous atmospheres. However, they must first calibrate the meter and use it according to the manufacturer's instructions. Inaccurate instruments can expose workers to excessive levels of toxic gas or an oxygen-deficient atmosphere. The only way to guarantee that an instrument will detect gas accurately is to test it.

"Bump test" your air-monitoring meter every day – before you use it. A bump test verifies that an air-monitoring meter is properly calibrated. You perform a bump test by exposing the meter to a known concentration of test gas. Compare the instrument reading to the actual quantity of gas present. If the instrument's response is within an acceptable tolerance range of the actual concentration, then the meter is calibrated properly.

Physical hazards

Physical hazards come in many different forms and can cause death or serious physical harm. Examples include:

- **Access problems.** In an emergency, entrants may not be able to exit quickly.
- **Absorbed chemicals.** Chemicals can be absorbed through the skin or other tissues or membranes such as the eyes.
- **Corrosive chemicals.** Corrosive chemicals can cause severe eye or skin damage if exposed workers are not wearing protective clothing or eyewear.
- **Falling objects.** Objects can fall into the space because topside openings are unguarded or improperly guarded.
- **Illumination problems.** Poor lighting makes it difficult for workers to enter, work in, and exit a permit space.
- **Inwardly converging surfaces.** Inwardly converging walls and downward sloping floors that taper to a smaller cross section can trap a worker.
- **Material that could trap or bury a person.** Loose materials drawn from the bottom of storage bins can suffocate or bury a worker. Liquids or materials that are suddenly released into the space can have the same effect.
- **Mechanical, electrical, hydraulic, and pneumatic energy.** Mechanical and hydraulic equipment can move unexpectedly. Workers servicing mechanical and hydraulic equipment can be seriously injured or killed if the energy is not properly controlled.

- **Noise.** Noise interferes with essential communication between workers in a confined space and those who are monitoring their work on the outside. High noise levels can impair hearing and cause hearing loss. Permit spaces can amplify sounds produced by tools and equipment.
- **Radiation.** Sources of radiation include x-rays, isotopes, lasers, and welders.
- **Slippery surfaces.** Wet, slippery surfaces increase the risk of falls. Leaks, spills, and condensation are common in permit spaces.
- **Extreme temperatures.** Hot environments put workers at risk for heat stress, especially when they do strenuous work or are wearing protective clothing. Cold environments make their tasks more difficult to accomplish.

Eliminating physical hazards. Ways to eliminate physical hazards in a confined space include:

- Locking out equipment (following the requirements in 1910.147, Lockout/Tagout)
- Blanking and blinding piping systems
- Physically separating piping systems from the space

Always evaluate the space in its normal state before eliminating hazards.

Evaluating confined spaces and permit spaces: 437-002-0146(4)

Determine if any of your confined spaces have hazards that make them permit spaces.

Do not allow any employees to enter a confined space until it has been fully evaluated.

At workplaces where confined spaces are being built, host employers or controlling contractors do not need to evaluate confined spaces unless:

- One of their employees will enter the space
- An employee of an employer responsible to the host employer or controlling contractor will enter the space
- A host employer or controlling contractor assumes control over the space

If your workplace has a permit space, your employees must know where it is located, that it is hazardous, and that it is a permit space.

- Allow employees to observe the evaluation of the space.
- Identify the space as a permit space. You can use signs, labels, or tags to identify the space.
- When conditions within the space change, re-evaluate it.
- Prevent unauthorized employees from entering the space.

If someone else will enter a permit space under your control (employees of another employer, for example), inform them:

- About all hazards or potential hazards in the spaces
- If the spaces have been evaluated before and what that evaluation discovered
- What your precautions or procedures are for entering the spaces

If your employees will enter a permit space, they must follow the requirements of your written permit-space program.

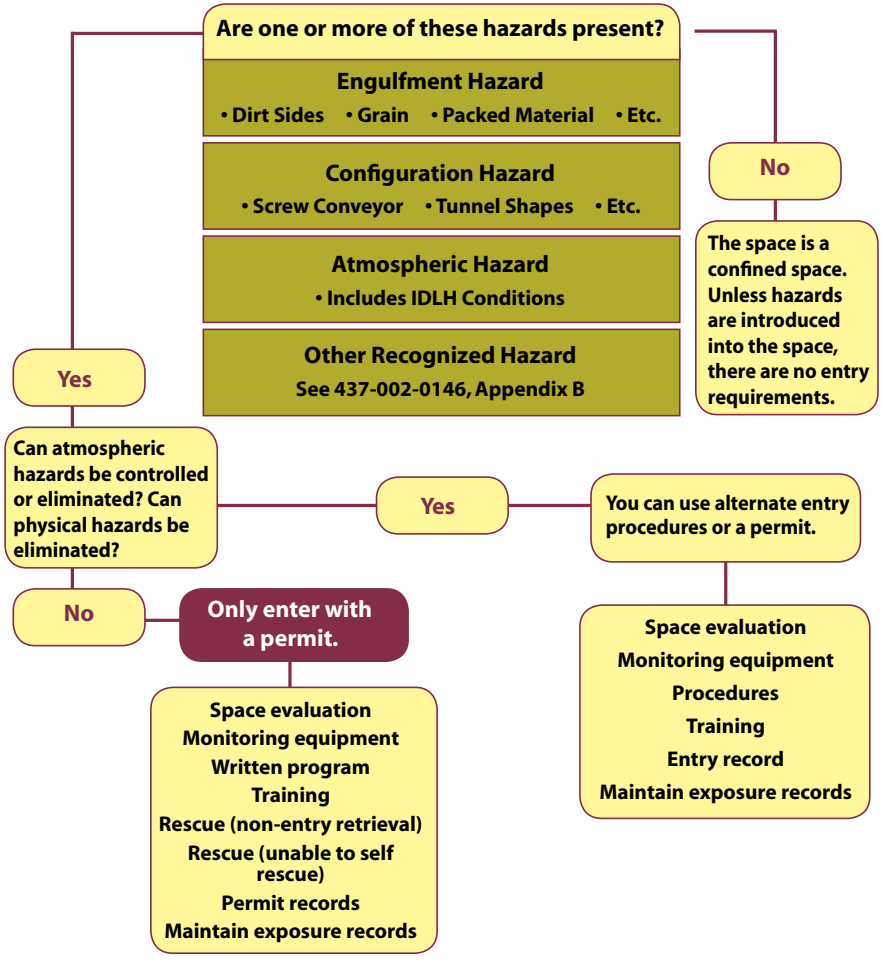
If you have mobile employees, you must determine whether there are confined spaces at the sites where they will be working. If confined spaces are present, the space must be evaluated to identify any physical or atmospheric hazards that make it a permit space.

The permit-space program and the entry permit: 437-002-0146(5)

If your employees will enter a confined space that has one or more of the hazards shown in the chart to the right, the space is a permit space and you must prepare a written permit-space program before they enter. Entry occurs when any part of a worker's body enters the space opening.

- An entry permit is required if atmospheric and physical hazards cannot be controlled or eliminated.
- You can use alternate entry procedures to enter a permit space if all physical hazards can be eliminated and all atmospheric hazards can be eliminated or controlled with continuous ventilation.

You determined that you have a confined space.



Requirements for a written permit space program

A written permit-space program must include:

- A procedure for issuing an entry permit
- Provisions for training employees about the written program and entry permits
- Measures taken to prohibit unauthorized employees from entering permit spaces
- The roles of entrants, attendants, entry supervisors, rescuers, and those who test or monitor the atmosphere in the space
- Provisions for training employees about their roles
- Duties of designated employees
- Instructions for identifying and evaluating hazards
- Methods for eliminating or controlling hazards
- Instructions for using and maintaining equipment
- Instructions for coordinating entry with another employer
- Procedures for concluding entry and canceling the entry permit

At fixed sites, the written program must include a list of all of your permit spaces (or the types of permit spaces if you have several of the same kind). For example, if you have sewer manholes, you do not have to include each one on the list; identify them as "sewer manholes," describe how to recognize them, and describe the hazards that make them permit spaces.

Employees must have access to the written permit-space program before entering a permit space.

Requirements for the entry permit

The entry permit describes acceptable entry conditions and verifies that a permit space is safe for workers to enter. No one can enter a permit space until a completed entry permit verifies that the hazards in the space have been eliminated or controlled. An entry supervisor must sign the entry permit, post it on the space where employees can see it, and cancel it after the work is finished.

The entry permit must include the following information:

- Description of the space that will be entered
- Purpose of the entry
- Entry date and the start and stop times of the work
- Hazards associated with the space
- Acceptable entry conditions
- Results of tests and monitoring performed to evaluate hazardous atmospheres
- Names or initials of the testers and the date the tests were performed
- Measures used before entry to isolate the space and eliminate or control hazards
- Names of entrants and attendants
- Name of the current entry supervisor
- Signature of the entry supervisor
- Communication procedures necessary for entrants and attendants to maintain contact during the entry
- Equipment necessary for safe entry
- Rescue services available and contact information for the service providers
- Permits for other work in the space (such as hot work)
- Description of problems encountered during entry

You must also develop a procedure for issuing an entry permit that describes how to:

- Evaluate the space's hazards
- Evaluate work-related hazards
- Identify safe entry conditions

Employees must have access to the completed permit before they enter a permit space so they can confirm that pre-entry preparations have been completed.

You must review your entry program when there is any reason to believe employees are not protected. Situations that require a review include:

- Unauthorized entry
- When a new hazard is identified
- When a condition prohibited by the permit occurs during entry
- When an injury or near miss occurs during entry
- When an employee reports concerns about the permit's effectiveness or the procedure for issuing the permit

When you revise your program, do not allow anyone into the affected space until the revisions are complete.

Permit entry: 437-002-0146(6)

Before workers enter a permit space, you must ensure that the hazards associated with the space have been eliminated or controlled. A completed entry permit verifies that hazards have been eliminated or controlled and the space is safe.

The entry supervisor must certify that the space is safe to enter, sign the entry permit, and post it on the space so that authorized entrants can see it.

Establishing safe entry conditions

Essential conditions for safe entry include:

- **Guarding the space.** Use warning signs or barriers to keep out unauthorized people and to protect entrants from falling objects.
- **Isolating the space.** Disconnect, lock out, or tag out hazardous equipment in the space. If you lock out equipment, remember that "lock out" includes testing to ensure the lockout method works.
- **Testing the space for hazardous atmospheres.** Test the atmosphere from outside the space for all potential atmospheric hazards, which may include oxygen; flammable gasses, dusts, or vapors; toxic gasses or vapors; and corrosive atmospheres. Provide entrants with test results. Re-test the space if an entrant believes that initial testing was inadequate.
- **Eliminating or controlling hazardous atmospheres.** Eliminate or control the hazards in the space then document the method and the steps necessary to eliminate or control the hazards. Allow entrants to observe testing, monitoring, and any other activity necessary to eliminate or control hazards.
- **Providing necessary equipment.** Ensure that entrants have the equipment they need to do their jobs (including rescue equipment) and that they know how to use the equipment.
- **Planning for emergencies.** Attendants must know how to respond to emergencies, including who to contact and how to remove entrants.

Maintaining safe entry conditions

When work begins inside the space, you must ensure safe conditions are maintained until the work is finished. Essential conditions for maintaining safe entry include:

- **Monitoring activity inside and outside the space.** Attendants must constantly monitor the space for hazards while employees are inside.
- **Maintaining communications between attendants and entrants.** Attendants and entrants must keep in contact with each other. They must know what communications equipment to use and how to use it.
- **Keeping unauthorized people away from the space.** The entry supervisor and the attendants are responsible for keeping people away.

If the space must be evacuated, do not allow re-entry unless you do either of the following:

- Evaluate the conditions in the space to ensure it is safe for re-entry and ensure that the permit notes the evacuation
- Issue a new entry permit

Equipment necessary for entering a permit space: 437-002-0146(7)

You must have all necessary equipment to ensure safe entry into permit spaces. This equipment can include:

- Testing and monitoring equipment
- Ventilating equipment to maintain acceptable entry conditions
- Communication equipment, such as a two-way radio, for communication between the attendant and entrants, and to initiate a rescue
- Appropriate lighting, so they can see and can exit the space quickly in an emergency
- Barriers or shields to protect them from hazards outside the space such as pedestrians and vehicles
- Ladders or similar equipment so they can enter and exit the space
- Rescue equipment, if they are unable to evacuate in an emergency
- Appropriate personal protective equipment

The equipment must be available to the employees at no cost, must be used in accordance with the instructions from the manufacturer, and the employees must be trained to use it properly.

Employees' duties and responsibilities: 437-002-0146(8)

Working in a permit space involves entrants, attendants, and entry supervisors. Before anyone enters, you must designate who has each of these duties.

Entrants are the employees you allow to enter a permit space. Attendants monitor the entrants' activities from outside the space. The entry supervisor ensures that attendants and entrants follow entry procedures.

Entrants must

- Know the about hazards that they may face during entry and the signs, symptoms, and consequences of exposure
- Communicate with the attendants so the attendants can monitor their status and warn them when they need to evacuate
- Tell the attendants about hazardous conditions in the space or symptoms of exposure
- Leave the space immediately when:
  - An order to evacuate is given by an attendant or the entry supervisor
  - An entrant recognizes any warning sign or symptom of exposure to a dangerous situation
  - An entrant detects a dangerous or hazardous condition
  - An evacuation alarm is activated

Attendants must

- Know the hazards entrants may face during entry and the signs, symptoms, and consequences of exposure
- Be aware of the behavioral effects of hazards on entrants
- Keep an ongoing count of entrants and ensure that the count identifies who is in the space
- Remain outside the space during entry operations until relieved by another attendant
- Communicate with entrants to monitor their status and to alert them if they need to evacuate
- Summon emergency responders as soon as entrants need to escape from the space
- Perform non-entry rescues following your established rescue procedure
- Do nothing that would interfere with monitoring and protecting an entrant

- Monitor activity inside and outside the space and order an immediate evacuation when:
- There is a hazardous condition in the space
- An entrant's behavior is affected by exposure to a hazard
- A situation outside the space could endanger the entrants
- It is not possible to perform the duties required of an attendant

An attendant can monitor more than one space at a time if the duties for one space do not interfere with duties for another space. If an attendant's attention is focused on one space – during a rescue, for example – all other spaces that the attendant is monitoring must be evacuated or another attendant must take over those duties.

When unauthorized people approach or enter a permit space while entry is under way, attendants must:

- Warn them to stay away from the space
- Tell them that they must exit immediately if they have entered the space
- Inform the authorized entrants and the entry supervisor if unauthorized people have entered the space

You can give attendants authority to remove unauthorized people who attempt to enter a space during entry operations as long as the attendants do not enter the space.

Entry supervisors must

- Know the hazards that entrants may face during entry, including the signs, symptoms, and consequences of exposure
- Understand how to control or eliminate hazards associated with the space
- Verify that all tests specified by the entry permit have been conducted and that all procedures and equipment specified by the permit are in place before signing the permit and allowing entry to begin
- Inform entrants and attendants about the hazards and conditions associated with the space and the methods used to eliminate or control the hazards
- Terminate the entry and cancel the entry permit as required by the entry procedure
- Verify that rescue service providers are available and that they can be contacted in an emergency
- Remove unauthorized people who enter or who attempt to enter the space during entry operations
- Re-evaluate conditions in the space whenever responsibility for an entry operation is transferred, new hazards are identified, or when the work performed in the space changes

Performing rescues: 437-002-0146(9)

Before you authorize employees to enter a permit space, you must ensure that trained emergency responders will be available if an entrant needs help. Responders must be able to reach the site promptly and know how to deal with the emergency. You can use an on-site rescue team or a third-party rescue service as long as the responder meets your needs in an emergency. Third-party rescue services must agree to provide the service. (Emergency responders are not required when you use alternate entry procedures.)

Those who do not understand permit-space hazards or who respond inappropriately are often the victims in many permit-space accidents. Keep in mind that many fire departments are not equipped to respond to permit-space emergencies.

Firefighters who are not on your designated rescue team and who respond to emergency (911) calls for a confined space rescue must comply with Subdivision 2/L, 437-002-0182, Oregon Rules for Fire Fighters.

Developing a rescue procedure

Before your employees enter a permit space, you must have a procedure for removing them when they are unable to evacuate. The procedure must include the process for summoning rescue services and transporting injured entrants to a medical facility. Safety Data Sheets (SDS) must be kept at worksites. If an entrant is exposed to a hazardous substance, that written material must be made available to the treating medical facility.

Performing non-entry rescues

Use non-entry rescue methods and equipment unless they would increase the overall risk to an entrant. Each entrant must use a chest or full-body harness with a retrieval line attached at the center of the entrant's back near shoulder level, above the entrant's head, or at a similar point that makes it possible to remove the entrant from a confined space. Equipment such as wristlets or ankle straps may be used if a chest or full-body harness is not feasible.

The other end of the retrieval line must be attached to a mechanical device or to a fixed point outside the space so that the rescue can begin immediately. A mechanical device must be available to retrieve entrants from permit spaces greater than five feet deep.

Designate a rescue person or team to perform rescues in a timely manner. Response time is based on the hazards associated with the space. For example, immediately dangerous to life or health (IDLH) hazards require an immediate response and responders must be available on site for the duration of the entry. All rescuers must be knowledgable in basic first aid and cardiopulmonary resuscitation (CPR) and at least one rescuer must be certified in first aid and CPR.

Rescuers must practice non-entry rescues within 12 months before an entry. Practice rescues must include:

- Every type of space in which the rescue team might perform rescues
- Removing people or mannequins from the actual permit spaces or a simulated space that has similar characteristics

Performing entry rescues

Consider entry rescues only when a non-entry rescue would increase the overall risk to an entrant or is not feasible.

Designate a rescue team that can respond in a timely manner, can rescue entrants efficiently, and has the appropriate equipment. Ensure that the rescue team has:

- Information about the hazards it may encounter during a rescue
- Access to the permit spaces they need to enter
- Appropriate personal protective equipment (PPE)
- Any other equipment necessary for safe entry

The team must practice rescues within12 months before an entry. Rescues must involve removing people or mannequins from the actual permit spaces or from spaces that have similar characteristics. Rescuers must have the same training as entrants, attendants, and entry supervisors. All rescue team members must be knowledgeable in basic first aid and CPR and at least one rescuer must be certified in first aid and CPR.

Experienced emergency responders must be available if an entrant needs help.

Mobile workers and rescue

When your workers are mobile, they do not need to do an annual practice rescue (either entry or non-entry) if the rescue team does a practice rescue in the space that needs to be entered.

The rescue team must have access to the space before the entry because they need to develop a rescue plan and practice before the actual entry. If the team has access to a space similar to the one that needs to be entered, they can use that space for the practice rescue instead.

Third-party rescue service providers

When a third-party rescue service is used, ensure that the service:

- Agrees to provide the service
- Is capable of performing all necessary rescue operations
- Is knowledgable in first aid and CPR and at least one member is certified in first aid and CPR

Third-party rescue service providers must:

- Obtain the evaluation information about every permit space they may need to enter
- Be familiar with procedures necessary to remove entrants from permit spaces in an emergency or when they are not able to evacuate
- Use the entry permit to identify all physical and atmospheric hazards in the space and determine the procedure to follow for entering the space

Third-party rescue services must be capable of performing all necessary rescue operations.

Alternate entry: 437-002-0146(10)

What is alternate entry?

Alternate entry is a set of specific procedures for entering a permit space without an entry permit; however, the space remains a permit space under alternate entry. The following sections of 437-002-0146 apply under alternate entry:

- Evaluation, 437-002-0146(4)
- Equipment, 437-002-0146(7)
- Alternate entry, 437-002-0146(10)
- Training, 437-002-0146(11)

Employees may enter a permit space under alternate entry only after you do one of the following:

- Eliminate all physical hazards and hazardous atmospheres in the space so that conditions that caused the hazards no longer exist
- Eliminate all physical hazards in the space and control all hazardous atmospheres with continuous ventilation

Alternate entry procedures

Develop and implement alternate entry procedures that address:

- The hazards associated with the space
- The methods used to eliminate the hazards
- The methods used to ensure that the hazards have been eliminated
- The methods used to test the space for all hazardous atmospheres
- The methods used to determine if unsafe conditions occur before or during entry
- The criteria and conditions for evacuating the space
- The methods for training employees in these procedures
- The methods for ensuring employees follow these procedures

Ensure that all employees who enter:

- Have the opportunity to observe the activities required to comply with the alternate entry procedures
- Have an effective means of communication, such as a two-way radio, cellphone, or voice (if other employees are present) to request help in an emergency

Documenting alternate entry

Document each entry. Include:

- The location of the space
- The hazards associated with the space
- Measures taken to eliminate the hazards
- Measures used to control hazardous atmospheres (when applicable)
- The identity of the direct-reading instruments used to test the atmosphere (when applicable)
- The results of atmospheric testing (when applicable)
- The entry date
- The duration of the entry
- Any conditions that caused the evacuation of the space
- The name, title, and signature of the person responsible for ensuring that the space is safe to enter

Keep the document where the space is located for the duration of the entry.

Alternate entry in continuous systems

Alternate entry cannot be used to enter a permit space that is a continuous system (such as a sewer) unless you segregate the area to be entered from the rest of the space, demonstrate that engulfment can't happen and the only hazard is atmospheric, or you demonstrate and document that the hazardous conditions do not exist within the entire system during the entry.

Alternate entry with continuous ventilation

When using ventilation to control hazardous atmospheres:

- Use only properly calibrated direct-reading meters to test the atmosphere
- Ensure that direct-reading instruments are used and tested according to the manufacturer's instructions
- Test the space for hazardous atmospheres before entering
- Ensure that employees do not enter the space until testing has verified that all hazardous atmospheres are controlled by ventilation
- Perform continuous monitoring for all hazardous atmospheres while employees are in the space

Rescue procedure not required under alternate entry

There is no requirement for a rescue procedure when workers enter a confined space under alternate entry because hazards in the space have been eliminated or controlled.

Evacuating a permit space under alternate entry

Employees must immediately evacuate a space:

- When monitoring indicates the presence of a hazardous atmosphere
- When a direct-reading meter used for monitoring fails
- When ventilation fails
- When a new hazard is identified or conditions in the space change

When a space is evacuated, it cannot be re-entered unless the conditions that caused the evacuation are corrected.

Re-entry must be treated and documented as a new entry.

Training employees: 437-002-0146(11)

Training employees involved in permit space work

Train employees involved in permit space activities so they acquire the understanding, knowledge, and skills necessary to safely perform their duties and their assigned responsibilities.

Training is required for new employees and for all other employees:

- Before an employee is assigned permit-space duties
- Before there is a change in an employee's assigned duties
- When there is a new permit space hazard for which an employee has not been trained
- When there are changes to the written permit-space program
- When a review of an entry permit identifies problems with an entry
- When there is a deviation from established procedures or an employee's knowledge of the procedures is inadequate

Record each employee's training, including the employee's name, the trainer's signature, the training date, and the employee's responsibilities. Employees must be able to inspect their training records.

Awareness training for employees

Awareness training is required for employees who work in areas (or who may work in areas) where permit spaces are present. The purpose of awareness training is to ensure that employees understand that their employer has permit spaces, there is a process for entering the spaces, and that they can identify the spaces.

Awareness training is not required for employees when the exposure to those spaces is negligible – such as office workers walking in a parking lot that has a sewer manhole or entering a building with a baghouse near it – as long as those employees have no other exposures to permit spaces. Awareness training is also not required when the entrances to all permit spaces are locked and access would require extraordinary means (such as a chop saw or cutting torch).

Awareness training must provide a basic overview of:

- The written permit-space program
- How to recognize a permit space
- How entry is authorized by the entry permit
- How entry is authorized by the alternate entry procedures (if used)

Repeat the training when there is a change in the written permit-space program and when there are new or previously unidentified permit spaces.

Entry operations at multi-employer worksites: 437-002-0146(12)

Before someone else's employees enter permit spaces under your control

Let their employers know about the hazards of those spaces and about any precautions or procedures that you require to protect your employees.

When your employees are working in a space, and someone else's employees will be working in or around that space, coordinate entry operations with the other employers so your employees are not exposed to hazards created or discovered by the other employees, and vice-versa.

After the operations are finished, discuss any hazards that employees created or encountered.

After your employees enter someone else's permit space

Let whoever is in control of that space (it might be a property owner or a general contractor) know about the precautions and procedures you followed and about any hazards that you or your employees found during entry.

Recordkeeping: 437-002-0146(13)

Permit entry. Keep cancelled entry permits for at least one year from the date the permit expires. Review permits within one year of their cancellation to ensure that the procedures for issuing them are still effective and the information on them still protects employees who enter the space.

Alternate entry. Keep the entry document where the space is located for the duration of the entry; after the entry, there is no requirement to keep it. However, the document may be helpful when you review the effectiveness of your confined space program.

Notes:

*Oregon*OSHA Services

Oregon OSHA offers a wide variety of safety and health services to employers and employees:

Appeals

503-947-7426; 800-922-2689; admin.web@oregon.gov

- Provides the opportunity for employers to hold informal meetings with Oregon OSHA on concerns about workplace safety and health.
- Discusses Oregon OSHA's requirements and clarifies workplace safety or health violations.
- Discusses abatement dates and negotiates settlement agreements to resolve disputed citations.

Conferences

503-378-3272; 888-292-5247, Option 1; oregon.conferences@oregon.gov

- Co-hosts conferences throughout Oregon that enable employees and employers to learn and share ideas with local and nationally recognized safety and health professionals.

Consultative Services

503-378-3272; 800-922-2689; consult.web@oregon.gov

- Offers no-cost, on-site safety and health assistance to help Oregon employers recognize and correct workplace safety and health problems.
- Provides consultations in the areas of safety, industrial hygiene, ergonomics, occupational safety and health programs, assistance to new businesses, the Safety and Health Achievement Recognition Program (SHARP), and the Voluntary Protection Program (VPP).

Enforcement

503-378-3272; 800-922-2689; enforce.web@oregon.gov

- Offers pre-job conferences for mobile employers in industries such as logging and construction.
- Inspects places of employment for occupational safety and health hazards and investigates workplace complaints and accidents.
- Provides abatement assistance to employers who have received citations and provides compliance and technical assistance by phone.

Public Education

503-947-7443; 888-292-5247, Option 2; ed.web@oregon.gov

- Provides workshops and materials covering management of basic safety and health programs, safety committees, accident investigation, technical topics, and job safety analysis.

Standards and Technical Resources

503-378-3272; 800-922-2689; tech.web@oregon.gov

- Develops, interprets, and gives technical advice on Oregon OSHA's safety and health rules.
- Publishes safe-practices guides, pamphlets, and other materials for employers and employees
- Manages the Oregon OSHA Resource Center, which offers safety videos, books, periodicals, and research assistance for employers and employees.

Need more information? Call your nearest Oregon OSHA office.

Salem Central Office

350 Winter St. NE
Salem, OR 97301-3882

Phone: 503-378-3272

Toll-free: 800-922-2689

Fax: 503-947-7461

en Español: 800-843-8086

Web site: www.orosha.org

Bend

Red Oaks Square
1230 NE Third St., Suite A-115
Bend, OR 97701-4374
541-388-6066
Consultation: 541-388-6068

Eugene

1140 Willagillespie, Suite 42
Eugene, OR 97401-2101
541-686-7562
Consultation: 541-686-7913

Medford

1840 Barnett Road, Suite D
Medford, OR 97504-8250
541-776-6030
Consultation: 541-776-6016

Pendleton

200 SE Hailey Ave.
Pendleton, OR 97801-3056
541-276-9175
Consultation: 541-276-2353

Portland

Durham Plaza
16760 SW Upper Boones Ferry Road, Suite 200
Tigard, OR 97224-7696
503-229-5910
Consultation: 503-229-6193

Salem

1340 Tandem Ave. NE, Suite 160
Salem, OR 97303
503-378-3274
Consultation: 503-373-7819

Oregon OSHA

440-2864 (11/14) OR-OSHA

DEPARTMENT OF CONSUMER & BUSINESS SERVICES

Facilities Management
The University of Iowa

HOT WORK PERMIT

STOP!

Avoid hot work or seek an alternative/safer method, if possible.

This *Hot Work Permit* is required for any temporary operation involving open flames or producing heat and/or sparks. This includes, but is not limited to: brazing, cutting, grinding, soldering, torch-applied roofing and welding.

Instructions

1. **Firesafety Supervisor:**

A. Specify the precautions to take

B. Fill out and keep **Part 1** during the hot work process

C. Issue **Part 2** to the person doing the job.

D. Keep **Part 2** on file for future reference, including signed confirmation that the one-hour fire watch and three-hour monitoring have been completed.

HOT WORK BY
☐ Employee
☐ Contractor _____

DATE	JOB NUMBER

LOCATION/BUILDING AND FLOOR

IDENTIFY OBJECT/SPECIFIC LOCATION

NATURE OF JOB

NAME (PRINT) AND SIGNATURE OF PERSON PERFORMING HOT WORK

I verify the above location has been examined, the precautions checked on the Required Precautions Checklist have been taken to prevent fire, and permission is authorized for this work.

NAME (PRINT) AND SIGNATURE OF FIRESAFETY SUPERVISOR/OPERATIONS SUPERVISOR

TIME STARTED: a.m. p.m. TIME FINISHED: a.m. p.m.

Permit Expires	DATE	TIME a.m. p.m.

Note: Emergency notification on back of form.
Use as appropriate for your facility.

To order additional hot work permits or other FM Global resources, order online 24 hours a day, seven days a week, at www.fmglobalcatalog.com.

FM Global

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Part 1

Required Precautions Checklist

Y	NA	
☐	☐	The fire pump is in operation and switched to automatic.
☐	☐	Control valves to water supply for sprinkler system are open.
☐	☐	Hose streams and extinguishers are in service/operable.
☐	☐	Hot work equipment in good working condition.
		Requirements within 35 ft. (11 m) of hot work
☐	☐	Ignitable liquid, dust, lint and oily deposits removed.
☐	☐	Explosive atmosphere in area eliminated.
☐	☐	Floors swept clean.
☐	☐	Combustible floors wet down, covered with damp sand or fire-resistive sheets.
☐	☐	Remove other combustible material where possible. Otherwise, protect with FM Approved welding pads, blankets and curtains, fire-resistive tarpaulins or metal shields.
☐	☐	All wall and floor openings covered.
☐	☐	FM Approved welding pads, blankets and curtains installed under and around work.
☐	☐	Protect or shut down ducts and conveyors that might carry sparks to distant combustible material.
		Hot work on walls, ceilings or roofs
☐	☐	Construction is noncombustible and without combustible covering or insulation.
☐	☐	Combustible material on other side of walls, ceilings or roofs is moved away.
		Hot work on enclosed equipment
☐	☐	Enclosed equipment cleaned of all combustible material.
☐	☐	Containers purged of ignitable liquid/vapor.
☐	☐	Pressurized vessels, piping and equipment removed from service, isolated and vented.
		Fire watch/hot work area monitoring
☐	☐	Fire watch will be provided during and for one (1) hour after work, including any break activity.
☐	☐	Fire watch is supplied with suitable extinguishers, and where practical, a charged small hose.
☐	☐	Fire watch is trained in use of equipment and in sounding alarm.
☐	☐	Fire watch may be required in adjoining areas, above and below.
☐	☐	Monitor hot work area for up to an additional three (3) hours after the one (1) hour fire watch.
☐	☐	**Other precautions taken:**

Facilities Management
The University of Iowa

HOT WORK PERMIT

STOP!

Avoid hot work or seek an alternative/safer method, if possible.

This *Hot Work Permit* is required for any temporary operation involving open flames or producing heat and/or sparks. This includes, but is not limited to: brazing, cutting, grinding, soldering, torch-applied roofing and welding.

Instructions

1. **Firesafety Supervisor:**

A. Specify the precautions to take

B. Fill out and keep **Part 1** during the hot work process (**Part 1A** is for quality assurance documentation, if necessary).

C. Issue **Part 2** to the person doing the job.

D. Keep **Part 2** on file for future reference, including signed confirmation that the one-hour fire watch and three-hour monitoring have been completed.

HOT WORK BY
☐ Employee
☐ Contractor _____

DATE	JOB NUMBER

LOCATION/BUILDING AND FLOOR

IDENTIFY OBJECT/SPECIFIC LOCATION

NATURE OF JOB

NAME (PRINT) AND SIGNATURE OF PERSON PERFORMING HOT WORK

I verify the above location has been examined, the precautions checked on the Required Precautions Checklist have been taken to prevent fire, and permission is authorized for this work.

NAME (PRINT) AND SIGNATURE OF FIRESAFETY SUPERVISOR/OPERATIONS SUPERVISOR

TIME STARTED: a.m. p.m. TIME FINISHED: a.m. p.m.

Permit Expires	DATE	TIME a.m. p.m.

Note: Emergency notification on back of form.
Use as appropriate for your facility.

To order additional hot work permits or other FM Global resources, order online 24 hours a day, seven days a week, at www.fmglobalcatalog.com.

FM Global

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Part 1A

Required Precautions Checklist

Y	NA	
☐	☐	The fire pump is in operation and switched to automatic.
☐	☐	Control valves to water supply for sprinkler system are open.
☐	☐	Hose streams and extinguishers are in service/operable.
☐	☐	Hot work equipment in good working condition.
		Requirements within 35 ft. (11 m) of hot work
☐	☐	Ignitable liquid, dust, lint and oily deposits removed.
☐	☐	Explosive atmosphere in area eliminated.
☐	☐	Floors swept clean.
☐	☐	Combustible floors wet down, covered with damp sand or fire-resistive sheets.
☐	☐	Remove other combustible material where possible. Otherwise, protect with FM Approved welding pads, blankets and curtains, fire-resistive tarpaulins or metal shields.
☐	☐	All wall and floor openings covered.
☐	☐	FM Approved welding pads, blankets and curtains installed under and around work.
☐	☐	Protect or shut down ducts and conveyors that might carry sparks to distant combustible material.
		Hot work on walls, ceilings or roofs
☐	☐	Construction is noncombustible and without combustible covering or insulation.
☐	☐	Combustible material on other side of walls, ceilings or roofs is moved away.
		Hot work on enclosed equipment
☐	☐	Enclosed equipment cleaned of all combustible material.
☐	☐	Containers purged of ignitable liquid/vapor.
☐	☐	Pressurized vessels, piping and equipment removed from service, isolated and vented.
		Fire watch/hot work area monitoring
☐	☐	Fire watch will be provided during and for one (1) hour after work, including any break activity.
☐	☐	Fire watch is supplied with suitable extinguishers, and where practical, a charged small hose.
☐	☐	Fire watch is trained in use of equipment and in sounding alarm.
☐	☐	Fire watch may be required in adjoining areas, above and below.
☐	☐	Monitor hot work area for up to an additional three (3) hours after the one (1) hour fire watch.
☐	☐	**Other precautions taken:** _____

Facilities Management
The University of Iowa

WARNING

HOT WORK IN PROGRESS! Watch for fire!

Instructions

1. ***Person performing hot work:*** Indicate time started and post permit at hot work location. After hot work is completed, indicate time and leave permit posted for fire watch.
2. ***Fire Watch:*** Watch area during hot work and for one (1) hour after completion. Prior to leaving area, perform final inspection, sign, leave permit posted and notify firesafety supervisor.
3. ***Monitor:*** Monitor area for additional three (3) hours. Perform final inspection, sign and return to firesafety supervisor.

HOT WORK BY
☐ Employee
☐ Contractor _____

DATE	JOB NUMBER

LOCATION/BUILDING AND FLOOR

IDENTIFY OBJECT/SPECIFIC LOCATION

NATURE OF JOB

NAME (PRINT) AND SIGNATURE OF PERSON PERFORMING HOT WORK

I verify the above location has been examined, the precautions checked on the Required Precautions Checklist have been taken to prevent fire, and permission is authorized for this work.

NAME (PRINT) AND SIGNATURE OF FIRESAFETY SUPERVISOR/OPERATIONS SUPERVISOR

TIME STARTED: a.m. p.m. TIME FINISHED: a.m. p.m.

Permit Expires	DATE	TIME a.m. p.m.

Fire watch signoff: Work area and all adjacent areas to which sparks and heat might have spread were inspected during the watch period and were found firesafe.

Signed:

Final checkup: Work area was monitored for three (3) hours following completion of the one (1) hour fire watch and found firesafe.

Signed:

Part 2

Required Precautions Checklist

Y	NA	
☐	☐	The fire pump is in operation and switched to automatic.
☐	☐	Control valves to water supply for sprinkler system are open.
☐	☐	Hose streams and extinguishers are in service/operable.
☐	☐	Hot work equipment in good working condition.
		Requirements within 35 ft. (11 m) of hot work
☐	☐	Ignitable liquid, dust, lint and oily deposits removed.
☐	☐	Explosive atmosphere in area eliminated.
☐	☐	Floors swept clean.
☐	☐	Combustible floors wet down, covered with damp sand or fire-resistive sheets.
☐	☐	Remove other combustible material where possible. Otherwise, protect with FM Approved welding pads, blankets and curtains, fire-resistive tarpaulins or metal shields.
☐	☐	All wall and floor openings covered.
☐	☐	FM Approved welding pads, blankets and curtains installed under and around work.
☐	☐	Protect or shut down ducts and conveyors that might carry sparks to distant combustible material.
		Hot work on walls, ceilings or roofs
☐	☐	Construction is noncombustible and without combustible covering or insulation.
☐	☐	Combustible material on other side of walls, ceilings or roofs is moved away.
		Hot work on enclosed equipment
☐	☐	Enclosed equipment cleaned of all combustible material.
☐	☐	Containers purged of ignitable liquid/vapor.
☐	☐	Pressurized vessels, piping and equipment removed from service, isolated and vented.
		Fire watch/hot work area monitoring
☐	☐	Fire watch will be provided during and for one (1) hour after work, including any break activity.
☐	☐	Fire watch is supplied with suitable extinguishers, and where practical, a charged small hose.
☐	☐	Fire watch is trained in use of equipment and in sounding alarm.
☐	☐	Fire watch may be required in adjoining areas, above and below.
☐	☐	Monitor hot work area for up to an additional three (3) hours after the one (1) hour fire watch.
☐	☐	**Other precautions taken:**

WARNING!

HOT WORK IN PROGRESS
Watch for fire!

In case of emergency:

Call: _____

At: _____

_____

_____

WARNING!

HAWKEYE on Safety
Be safe, and if it looks unsafe...ACT!
Facilities Management
The University of Iowa

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The ABCs of construction site safety

Oregon OSHA

A Division of the
Department of Consumer
and Business Services

Safe jobs are smart business

One serious injury can stop the growth of your business in its tracks.

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Oregon OSHA

On the cover: Crane operator

The ABCs of construction site safety

Oregon OSHA

A Division of the Department of Consumer and Business Services

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About this guide

This guide consists of 28 "A-to-Z" workplace safety topics for construction-industry employers. Most topics include key construction-industry rules and summarize what you need to do to comply. If you are looking for a primer on our workplace safety and health rules for the construction industry, this guide is a good place to start. It does not cover all of our construction rules but most topics include links to related rules and other important information so that you can learn more.

Need more information or help?

- Oregon OSHA offers a variety of services including confidential, free safety, health, and ergonomic consultations in addition to no-cost workshops. Oregon OSHA's enforcement officers also provide pre-job conferences for construction companies.
- Oregon OSHA's program directives and interpretations offer additional guidance for complying with Oregon OSHA rules.
- Oregon OSHA's Resource Center has a large selection of books and periodicals as well as the American National Standards Institute (ANSI) and other consensus standards; the staff can provide technical and research assistance. The Resource Center also has an audiovisual library covering vehicle safety, respiratory health, toxic materials, hazard communication, ergonomics, hearing conservation, asbestos, general safety, industrial hygiene, accident investigation, confined work spaces, bloodborne pathogens, safety committees, construction, and more.
- The Resource newsletter focuses on safe work practices and news you can use to make your workplace safer and healthier. You can subscribe and sign up online.

This guide

ABCs of construction site safety is an Oregon OSHA Standards and Technical Resources Section publication.

Thanks to the following individuals:

Patricia Young: Oregon OSHA, design and layout

Mark Peterson: DCBS Communications, editing and proofing

Questions or comments?

We'd like to hear from you.

Contact us at **503-378-3272** or **tech.web@oregon.gov**

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Oregon OSHA

Accident prevention and accident investigation

Accident prevention responsibilities – Division 3, Subdivision C, 1926.20(b)

It is the employer's responsibility to maintain programs that comply with Oregon OSHA's construction rules.

- Such programs must provide for frequent and regular inspections of the job sites, materials, and equipment by competent persons designated by the employer.
- Use of machinery, tools, material, or equipment that does not comply with applicable requirements of this rule is prohibited. Machines, tools, material, or equipment must be identified as unsafe by tagging or locking the controls to make them inoperable or must be physically removed from the place of operation.
- The employer must permit only those employees qualified by training or experience to operate machinery or equipment.

Employer responsibilities – Division 1, 437-001-0760(1)

The employer must ensure that employees are properly instructed and supervised in the safe operation of any machinery, tools, equipment, process, or practice that they are authorized to use.

The employer must take all reasonable means to require employees:

- To work and act in a safe and healthful manner
- To conduct their work in compliance with all applicable safety and health rules

- To use all means and methods that are necessary to safely accomplish all work where employees are exposed to a hazard
- Not to remove, displace, damage, destroy, or carry off any safety device, guard, notice, or warning provided for use in any employment or place of employment when such use is required by applicable safety and health rules

Investigations of injuries – Division 1, 437-001-0760(3)

The employer must investigate every lost-time injury to determine the means that should be taken to prevent recurrence. The employer must promptly install any safeguard or take any corrective measure indicated or found advisable.

Supervisors or people in charge of work are agents of the employer in the discharge of their authorized duties and are at all times responsible for:

- The execution in a safe manner of the work under their supervision
- The safe conduct of their crew while under their supervision
- The safety of all employees under their supervision

Barricades and other traffic controls

Traffic control – Division 3, Subdivision G, 437-003-0420

- Adequate, appropriate traffic controls must be provided for all operations on or adjacent to a highway, street, or roadway. The traffic controls must conform to the Millennium Edition of the (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), December 2000.
- Barricades for protection of employees must conform to the Millennium Edition of the (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), December 2000.

  Note: *Employers can use the most current edition of the MUTCD.*
- Signaling by flaggers and the use of flaggers, including warning garments worn by flaggers, must also conform to the Millennium Edition of the (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), December 2000.

  Note: *Flagger's warning garments must conform to the MUTCD. Construction employees, other than flaggers, exposed to highway type moving vehicles in construction zones and street/highway traffic must wear highly visible upper body garments that comply with 437-003-0134(7).*

Vehicle drivers and riders – Division 3, Subdivision O, 437-003-3224(12)

- Traffic control: Employees must set up appropriate traffic controls when they stop on or adjacent to a highway, street, or road in a way that creates a hazard and when traffic cannot adjust safely on its own. The controls must conform to the Millennium Edition of the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), December 2000.
- Employers who follow the most current edition of the Oregon Temporary Traffic Control Handbook for Operations of Three Days or Less comply with this requirement.

14' 0"
ROAD
DAMAGE

Chemicals

Hazard communication – Division 3, Subdivision D, 1926.59

Employers must prepare a hazard communication program if their employees use or may be exposed to hazardous chemicals. The purpose of the hazard communication rule is to ensure that all hazardous chemicals are evaluated and employees get the information by a hazard communication program.

The hazard communication rule applies to any hazardous chemical in which employees may be exposed under normal conditions of use, or in a foreseeable emergency. A "hazardous chemical" is any chemical that presents a physical or health hazard.

Health hazards produce acute or chronic health effects and include carcinogens, toxic agents, irritants, corrosives, and sensitizers. Physical hazards include compressed gases, explosives, flammables, organic peroxides, oxidizers, and unstable (reactive) agents.

Contractors' employees must also be informed about the hazardous chemicals they may be exposed to. The written hazard communication program must include the methods the employer will use to provide contractors' employees on-site access to safety data sheets (SDS); the methods to inform them of any precautionary measures; and methods to inform other employees of the labeling system used in the workplace.

The employer must ensure that each container of hazardous chemicals in the workplace is labeled, tagged, or marked to identify the hazardous chemicals and appropriate hazard warnings.

What do you think is in this bottle?

Employees need to understand the information provided by the pictograms, signal word, hazard statement, and precautionary statements on the container label provided by the chemical manufacturer, importer, or distributor.

The employer must maintain copies of the required SDS for each hazardous chemical, and must ensure that they are readily accessible during each work shift by employees when they are in their work areas. When employees must travel between workplaces during a work shift, the SDS may be kept at the primary workplace facility; however, the employer must ensure that employees can immediately obtain the required information in an emergency.

Questions that an employer needs to consider

- Where do you keep your SDSs?
- If they are in someone's office, how do you ensure information access when that person is unavailable, sick, or on vacation?
- How do you ensure access after normal working hours, weekends, or holidays?
- If you have more than one shift, do all employees on all shifts have the same access?
- How do you maintain access to employee exposure and medical records? Subdivision C, 1926.33

Confined Spaces

Confined spaces – Division 2, Subdivision J, OAR 437-002-0146

(applies to both general industry and construction employers)

When workers enter a confined space to do construction work, they can encounter toxic gases, corrosive chemicals, flammable solvents, or machines that start unexpectedly. If something goes wrong, a confined space can be difficult or impossible to exit. And would-be rescuers can share the fate of those they are trying to rescue.

Key sections of OAR 437-002-0146 include:

- Evaluation, 437-002-0146(4)
- Permit-required confined space entry programs and permits, 437-002-0146(5)
- Permit entry, 437-002-0146(6)
- Equipment, 437-002-0146(7)
- Personnel, 437-002-0146(8)
- Rescue, 437-002-0146(9)
- Alternate entry, 437-002-0146(10)
- Training, 437-002-0146(11)
- Multi-employer worksites, 437-002-0146(12)
- Records, 437-002-0146(13)

Evaluation – Division 2, Subdivision J, OAR 437-002-0146(4)

It is the employer's responsibility to determine if any of their confined spaces are permit-required confined spaces. Employers must prohibit employees from entering unevaluated confined spaces until it is fully evaluated. Effective measures to prevent unauthorized employees from entering permit spaces must be taken.

Permit-required confined space entry program and permits – Division 2, Subdivision J, OAR 437-002-0146(5)

Employers must develop and implement a written program that describes the means, practices, and procedures for employees to safely identify and enter permit spaces.

Rescue – Division 2, Subdivision J, OAR 437-002-0146(9)

It is the employer's responsibility, before employees enter a permit space, to develop and implement procedures to remove entrants in the event of an emergency or when they are unable to evacuate without outside assistance.

Training - Division 2, Subdivision J, OAR 437-002-0146(11)

Employers must train each employee involved in permit space activities so they have the understanding, knowledge, and skills necessary to safely perform their duties, according to their assigned responsibilities.

CC: Cranes

Cranes and derricks — Division 3, Subdivision CC

This rule covers requirements for the safe use of cranes and derricks used in construction. Some key sections in Subdivision CC include:

- Scope, 1926.1400
- Ground conditions, 1926.1402
- Assembly/disassembly – general requirements, 1926.1404
- Power line safety (up to 350 kV) – equipment operations, 1926.1408
- Inspections, 1926.1412
- Operation, 1926.1417
- Authority to stop operation, 1926.1418
- Training, 1926.1430
- Hoisting personnel, 1926.1431

Assembly/disassembly requirements covered in 1926.1404 include:

- Manufacturer prohibitions
- Manufacturer assembly/disassembly procedure
- Employer assembly/disassembly procedure

Inspection requirements covered in 1926.1412 include:

- Repaired/adjusted equipment, 1926.1412(b)
- Post assemble
- Each shift
- Monthly
- Annual comprehensive

Operation requirements covered in 1926.1417 include:

- Operation procedures, 1926.1417(b)
- Leaving the equipment unattended, 1926.1417(e)
- Capacity, 1926.1417(o)

Training requirements covered in 1926.1430 include:

- Overhead power lines, 1926.1430(a)
- Signal persons, 1926.1430(b)
- Operators, 1926.1430(c)

Division 3 – construction rules

Division 3, which includes all of Oregon OSHA's safety and health rules for the construction industry, has the following subdivisions:

- C: General Safety and Health Provisions
- CC: Cranes and Derricks in Construction
- D: Occupational Health and Environmental Controls
- E: Personal Protective and Life Saving Equipment
- F: Fire Protection and Prevention
- G: Signs, Signals, and Barricades
- H: Materials Handling, Storage, Use, and Disposal
- I: Tools – Hand and Power
- J: Welding and Cutting
- K: Electrical
- L: Scaffolding
- M: Fall Protection
- N: Helicopters, Hoists, Elevators, and Conveyors
- O: Motor Vehicles, Mechanized Equipment, and Marine Operations
- P: Excavations
- Q: Concrete and Masonry Construction
- R: Steel Erection
- S: Underground Construction, Caissons, Cofferdams, and Compressed Air
- T: Demolition
- U: Blasting and Use of Explosives
- V: Power Transmission and Distribution
- W: Rollover Protective Structures; Overhead Protection
- X: Stairways and Ladders
- Z: Toxic and Hazardous Substances

Oregon OSHA also has program directives and interpretations of its rules.

Note: When a specific type of equipment, process, or practice is *not* limited to the construction industry, the provisions in other Oregon OSHA divisions will apply. See OAR 437-003-0005, *Additional Applicability*.

Standards and rules are available online at www.orosha.org.

Electrical

Oregon OSHA's electrical requirements for the construction industry are in Division 3, Subdivision K and include the following sections:

- General requirements
- Installation safety requirements
- Safety-related work practices (including lockout/tagout)
- Safety-related maintenance and environmental considerations
- Safety requirements for special equipment

Typical "Spider box" supplies GFCI-protected receptacle for use on construction sites.

Branch circuits – Division 3, Subdivision K, 437-003-0404

- All 125-volt, single-phase, 15-, 20-, and 30-ampere receptacles on construction sites that are for temporary power and are available for use by employees, must have approved ground-fault circuit interrupters (GFCIs).
- GFCI protection must be at the outlet end of the circuit. Extension cords or other devices with listed ground-fault circuit interrupter protection for personnel identified for portable are acceptable.
- Receptacles more than 125-volt, single phase, 30-amperes must have protection that complies with GFCI protection above, or an assured equipment grounding conductor program.

Working near overhead high-voltage lines and equipment – Division 3, Subdivision K, 437-003-0047

Do not enter or perform any activity (such as handling, erecting, operating, transporting, or storing any tools, equipment, or materials, moving a building or structure) within the restricted space surrounding an overhead high-voltage line or equipment unless:

- You are the owner, an authorized employee, or authorized (in writing) agent of the overhead high voltage system.
- Proper notification is provided and the line and equipment is de-energized and visibly grounded by the owner of the high-voltage system or authorized agent, or accidental contact is prevented by use of insulating barriers or guards.
- Insulated lines (not tree wire) and equipment designed and engineered to allow only incidental contact are installed by the owner of the high-voltage system or authorized agent.

Restricted space

- For lines rated more than 600 V to 50 kV, restricted space extends 10 feet in all directions from the surface of the line or equipment.
- For lines rated over 50 kV, restricted space extends 10 feet plus 0.4 inch for each one kV over 50 kV, or twice the length of the insulator (but never less than 10 feet) in all directions from the surface of the line or equipment.
- For equipment or structures in transit, on level surfaces, restricted space extends four feet in all directions from lines or equipment rated 50 kV or less, 10 feet in all directions for lines or equipment rated over 50 kV, and 16 feet in all directions for lines or equipment rated over 345 kV up to and including 750 kV.

Fall Protection

Oregon OSHA's fall protection requirements for the construction industry are in Division 3, Subdivision M, and include the following sections:

- Scope, application, and definitions, 1926.500
- Duty to have fall protection (general fall protection), 437-003-1501
- Fall protection systems criteria and practices, 1926.502, 437-003-0502, 437-003- 1502, and 437-003-2502.
- Training requirements, 437-003-0503

General fall protection – Division 3, Subdivision M, 437-003-1501

Except where permitted by another standard, when employees are exposed to a hazard of falling 6 feet or more to a lower level, the employer must ensure that fall protection systems are provided, installed, and implemented according to the criteria in 1926.502, 437-003-0502, 437-003- 1502, and 437-003-2502. In addition, each employee working less than 6 feet above dangerous equipment must be protected from falls into or onto dangerous equipment by guardrail systems or equipment guards.

Holes: Each employee on walking/working surfaces must be protected from falling through holes (including skylights) more than six feet above lower levels. Each employee on a walking/working surface must be protected from objects falling through holes (including skylights) and from tripping in or stepping into holes (including skylights) ***by covers***.

Wall openings: Each employee working on, at, above, or near wall openings (including those with chutes attached) where the outside bottom edge of the wall opening is six feet or more above lower levels and the inside bottom edge of the wall opening is less than 39 inches above the walking/working surface, must be protected from falling.

Established floors, mezzanines, balconies, and walkways: Each employee on established floors, mezzanines, balconies, and walkways, with an unprotected side or edge six feet or more above a lower level, must be protected from falling.

Excavations: Each employee at the edge of an excavation six feet or more in depth must be protected from falling when the excavations are not readily seen because of plant growth or other visual barrier. Each employee at the edge of a well, pit, shaft, and similar excavation six feet or more in depth must be protected from falling.

Each employee must be protected from falls into or onto dangerous equipment, regardless of the fall distance.

When an employee is exposed to falling objects, the employer must have each employee wear a hard hat and must implement an additional measure of protection such as erecting toeboards, screens, or guardrail systems; erecting a canopy structure; or barricading the area and prohibiting employees from entering the barricaded area.

Although he is wearing a harness, wouldn't you want to look at the rest of his fall protection system?

Guarding

Oregon OSHA's equipment guarding requirements for the construction industry are in Division 3, Subdivision I and include the following sections:

- General requirements, 1926.300
- Hand tools, 1926.301
- Power-operated hand tools, 1926.302
- Powder-actuated tools, 437-003-0925
- Abrasive wheels and tools, 1926.303
- Woodworking tools, 1926.304
- Jacks – lever and ratchet, screw, and hydraulic, 1926.305

Condition of tools: All hand and power tools and similar equipment, whether furnished by the employer or the employee, must be maintained in a safe condition.

Guarding: When power-operated tools are designed to accommodate guards, they must be equipped with guards when in use. Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating, or moving parts of equipment must be guarded if employees could contact them.

Types of guarding: One or more methods of machine guarding must be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips, and sparks.

Guarding abrasive wheel machinery requirements are in Division 3, **Subdivision I**, 1926.303.

Health hazards

Oregon OSHA's requirements covering construction-industry health hazards are in Division 3, Subdivision D and include the following sections:

- Medical services and first aid, 1926.50
- Sanitation, 1926.51
- Drinking water, 437-003-0015
- Toilets, 437-003-0020
- Occupational noise exposure, 1926.52
- Ionizing radiation, 1926.53
- Non-ionizing radiation, 1926.54
- Illumination, 1926.56
- Ventilation, 1926.57
- Hazard communication, 1926.59
- Methylenedianiline (MDA), 1926.60
- Lead, 1926.62

Toxic and hazardous substances

Requirements covering toxic and hazardous substances are in Division 3, Subdivision Z and include:

- Air contaminants, 437-003-1000
- Asbestos, 1926.1101
- Chromium, 1926.1126
- Cadmium, 1926.1127
- Methylene Chloride, 1926.1152

Make sure you stay hydrated when working in the heat. (WGN Blog)

Silica is not just dust. It is hazardous to your health.

Safety training and education – Division 3, Subdivision C, 1926.21(b)

- Employees required to handle or use poisons, caustics, and other harmful substances must be instructed about safe handling and use and be made aware of the potential hazards, personal hygiene, and personal protective measures required.
- At job sites where harmful plants or animals are present, employees who may be exposed must be instructed about the potential hazards, how to avoid injury, and the first-aid procedures in the event of injury.
- Employees handling or using flammable liquids, gases, or toxic materials must be instructed in the safe handling and use of these materials and made aware of other specific requirements in Division 3, **Subdivision C**.

Whether it is toxic adhesives, asbestos, silica, lead, or countless other occupational health dangers, employees must be instructed on the hazards and control measures.

Employer's responsibilities – Division 1, 437-001-0760(1)

- The employer is responsible for providing controls necessary to protect employees' health from harmful or hazardous conditions and for maintaining such controls in good working order.
- Every employer must inform the employees regarding the known health hazards to which they are exposed, the measures that have been taken for the prevention and control of such hazards, and the proper methods for using such controls.

Inspections

Oregon OSHA rules that have requirements for workplace inspections include:

Safety training and education – Division 3, Subdivision C, 1926.21(b)

The employer must instruct each employee how to recognize and avoid unsafe conditions and about any Oregon OSHA regulations applicable to his work.

Accident prevention responsibilities – Division 3, Subdivision C, 1926.20(b)

It is the employer's responsibility to initiate and maintain programs necessary to comply with 1926.20(b). Such programs must provide for frequent and regular inspections of the job sites, materials, and equipment to be made by competent persons designated by the employers.

Use of any machinery, tool, material, or equipment that does not comply with applicable Division 3 requirements is prohibited. The machine, tool, material, or equipment must either be identified as unsafe by tagging or locking the controls to make them inoperable or must be physically removed from its place of operation.

The employer must only permit employees qualified by training or experience to operate equipment and machinery.

Safety committees – Division 1, 437-001-0765(7)

Employers who have safety committees must establish procedures for conducting workplace safety and health inspections. People trained in hazard identification must conduct the inspections.

Inspections must be conducted quarterly at primary fixed locations, office environments, and satellite locations. Inspections at mobile work locations, infrequently visited sites, and sites that do not lend themselves to quarterly inspections, must be conducted as often as the safety committee determines is necessary.

Should this worker begin his inspection at his hard hat?
(Source: Paul A. Anderson, Cal/OSHA Hazard Compliance Unit-North)

Job Hazard Analysis

Job hazard analysis – or JHA – is an industry best practice method of identifying, assessing, and controlling hazards associated with a specific job. A JHA breaks a job down into tasks; each task is evaluated to determine if there is a better, safer way to do it. A job-hazard analysis works well for jobs with difficult-to-control hazards and jobs with histories of accidents or near misses. JHAs for complex jobs can take a considerable amount of time and expertise to develop. You may want to enlist the help of a safety professional for such tasks.

Most Oregon OSHA rules do not specifically require a JHA. However, employers are required to take the necessary steps to ensure that jobs are safe and healthful. A JHA helps fulfill this requirement. Employers applying for Oregon OSHA's Safety and Health Achievement Recognition Program (SHARP) and the Voluntary Protection Program (VPP) conduct JHAs.

Key steps in a JHA:

- Prepare: Review accident histories, involve employees, conduct risk assessment, and prioritize jobs based on hazardous exposures. Often, jobs need to be broken into tasks to better analyze the steps involved.
- Observe the task and list the steps required to accomplish it.
- Identify hazards in each step.
- Another hazard tracking method is categorizing into the following types: struck-by, struck-against, contact-by, contact-with, caught-on, caught-in, caught-between, fall-to-surface, fall-to-below, overexertion, bodily reaction, and overexposure.
- Develop hazard controls (engineering controls, management controls, PPE, and/or interim measures).
- Write a safe job procedure.

JOB HAZARD ANALYSIS

JOB NAME:

CONSTRUCTION PHASE:

START DATE: PAGE 1 OF

OPERATION	HAZARD	ACTION TO BE TAKEN

Compliments of Howard S. Wright Constructors

Keep the site clean

General safety and health provisions – Division 3, Subdivision C, 1926.20

Contractor requirements: No contractor or subcontractor for any part of the contract work can require any laborer or mechanic employed in the performance of the contract to work in surroundings or under working conditions that are unsanitary, hazardous, or dangerous to their health or safety.

Housekeeping – Division 3, Subdivision C, 1926.25

- During the construction, alteration, or repair work, forms and scrap lumber with protruding nails and all other debris must be cleared from work areas, passageways, and stairs in and around buildings or other structures.
- Combustible scrap and debris must be removed at regular intervals during the course of construction. A safe means must be provided for removal.
- Containers must be provided for the collection and separation of waste, trash, oily and used rags, and other refuse. Containers used for garbage and other oily, flammable, or hazardous wastes, such as caustics, acids, harmful dusts, etc., must be equipped with covers. Garbage and other waste must be disposed of at frequent, regular intervals.

Sanitation – Division 3, Subdivision D, 1926.51

Sanitation requirements for construction sites in 1926.51 cover:

- Potable water, 1926.51(a)
- Drinking water, 437-003-0015
- Nonpotable water, 1926.51(b)
- Toilets at construction jobsites, 1926.51(c)

See also Oregon OSHA program directive **A-97**, Toilet facilities: reasonable accessibility

General requirements for storage – Division 3, Subdivision H, 1926.250(a)

- All materials stored in tiers must be stacked, racked, blocked, interlocked, or secured to prevent sliding, falling, or collapse.
- Maximum safe load limits of floors within buildings and structures, in pounds per square foot, must be conspicuously posted in all storage areas, except for floor or slab on grade. Maximum safe loads must not be exceeded.
- Aisles and passageways must be kept clear to provide for the free and safe movement of material handling equipment or employees. Such areas must be kept in good repair.

Any issues here?

Housekeeping: Storage areas must be kept free from materials that constitute tripping, fire, explosion hazards, or harbor pests. Vegetation must also be controlled when necessary.

Ladders and stairways

Oregon OSHA's construction requirements covering ladders and stairways are in Division 3, Subdivision X, and include the following sections:

- Scope, application, and definitions, 1926.1050
- General requirements, 1926.1051
- Stairways, 1926.1052
- Ladders, 1926.1053
- Extension ladders, 437-003-0065
- Training requirements, 1926.1060

Training requirements – Division 3, Subdivision X, 1926.1060

The employer must provide a training program for each employee using ladders or stairways. The program must enable each employee to recognize ladder and stairway hazards and must train each employee how to minimize the hazards.

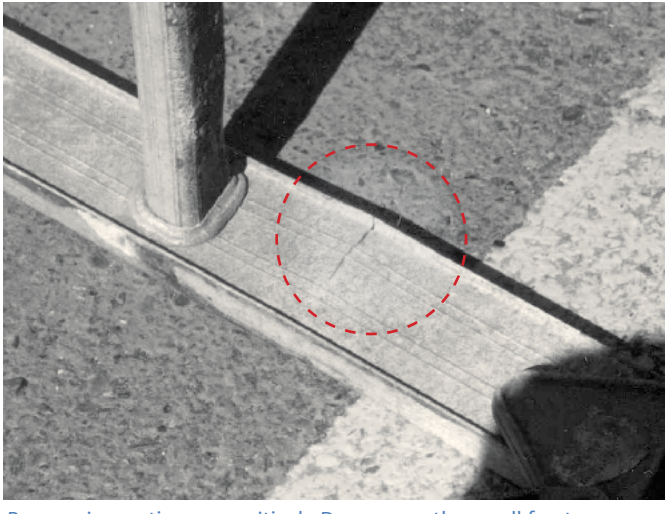
The employer must ensure that each employee has been trained by a competent person in the following areas:

- The nature of fall hazards in the work area
- The correct procedures for erecting, maintaining, and disassembling the fall protection systems to be used
- The proper construction, use, placement, and care in handling of all stairways and ladders
- The maximum intended load-carrying capacities of ladders used
- The requirements in Division 3, **Subdivision X**

Retraining must be provided for each employee as necessary.

Ladder safety essentials include:

- Appropriate selection
- Regular inspection
- Proper setup
- Safe use
- Proper maintenance and storage
- Training



Pre-use inspections are critical. Do you see the small fracture in this picture?

Medical and first aid

First aid and medical attention – Division 3, Subdivision C, 1926.23

First-aid services and provisions for medical care must be made available by the employer for every employee covered by these requirements.

Medical services and first aid – Division 3, Subdivision D, 1926.50

Key requirements:

- The employer must ensure the availability of medical personnel for advice and consultation on matters of occupational health.
- Provisions must be made for prompt medical attention in case of serious injury before commencement of a project.
- In the absence of an infirmary, clinic, hospital, or physician reasonably accessible to the worksite, a person who has a valid certificate in first-aid training from the U.S. Bureau of Mines, the American Red Cross, or equivalent training, must be available at the site to render first aid.

- First-aid supplies must be easily accessible when required. The contents of the first-aid kit must be placed in a weatherproof container with individual sealed packages for each type of item, and must be checked by the employer before being sent out on each job and at least weekly on each job to ensure that the expended items are replaced.
- Proper equipment for prompt transportation of the injured person to a physician or hospital, or a communication system for contacting necessary ambulance service, must be provided.
- Where 911 services are not available, the phone numbers of the physicians, hospitals, or ambulances must be conspicuously posted.

Appendix A to 1926.50, First-aid kits (Non-mandatory), includes the following points:

- Employers should evaluate the need for additional first-aid kits at the worksite, including additional first-aid equipment and supplies.
- Employers, who have unique or changing first-aid needs in their workplace, may need to enhance their first-aid kits. Advice from the local fire or rescue department or medical professionals may be helpful.
- If employees may be exposed to blood or other potentially infectious materials while using first-aid supplies, employers must provide personal protective equipment such as gloves, gowns, face shields, masks, and eye protection.

Note: Employers with employees in the construction industry who have occupational exposure to blood or other potentially infectious materials must follow the requirements in Division 2, Subdivision Z, 1910.1030 *Bloodborne Pathogens*.

Noise

Occupational noise exposure – Division 3, Subdivision D, 1926.52 and 437-003-0027

Whenever an employee is exposed to noise at a construction site, the requirements of Division 2, Subdivision G, Occupational Noise Exposure, **1910.95** apply. These requirements cover:

- Permissible exposure limits
- Hearing conservation program, 1910.95(c)
- Monitoring, 1910.95(d)
- Employee notification, 1910.95(e)
- Observation of monitoring, 1910.95(f)
- Audiometric testing, 1910.95(g)
- Hearing protectors, 1910.95(i)
- Hearing protector attenuation, 1910.95(j)
- Training program, 1910.95(k)
- Access to information and training materials, 1910.95(l)
- Recordkeeping, 1910.95(m)

Hours per day	Sound level (dBA)
8.0	90
6.0	92
4.0	95
3.0	97
2.0	100
1.5	102
1.0	105
0.25 or less	115

Employers must have a hearing conservation program whenever employee noise exposures equal or exceed an eight-hour time-weighted average sound level (TWA) of 85 dBA.

When employees are exposed to sound levels exceeding those listed in the table on the facing page, administrative or engineering controls must be used.

Concrete cutting is often around 110 to 115 dBA.

Organize a safety committee or hold safety meetings

Safety committees and safety meetings – Division 1, 437-001-0765

The purpose of safety committees and safety meetings is to bring employees and management together in a non-adversarial, cooperative effort to promote workplace safety and health. Safety committees and safety meetings will assist you make continuous improvement to your safety and health programs.

If more than half of your employees report to construction sites, you can have a safety committee or hold safety meetings.

Safety meetings must:

- Include all available employees
- Include at least one employer representative authorized to ensure correction of safety and health issues
- Be held on company time and attendees paid at their regular rate of pay

Safety meetings must occur at least monthly and before the start of each job that lasts more than one week.

Safety meetings must include discussions of:

- Safety and health issues
- Accident investigations, causes, and the suggested corrective measures

Employers in construction, utility work, and manufacturing must document, make available to all employees, and keep for three years a written record of each meeting that includes the following:

- Hazards related to tools, equipment, work environment, and unsafe work practices identified and discussed during the meeting
- The date of the meeting
- The names of those attending the meeting

If you are a subcontractor on a multi-employer worksite, your employees may attend the prime contractor's safety meetings. You may keep the minutes from these meetings as a part of your records. If you choose this option, you must still meet to discuss accidents involving your employees.

Personal protective equipment (PPE)

Personal protective equipment – Division 3, Subdivision E, 437-003-0134

The employer is responsible for requiring employees to wear appropriate PPE in all operations where there is an exposure to hazards or where this requirement indicates the need for using such equipment.

Personal protective and life saving equipment – Division 3, Subdivision E

This rule covers requirements for the use, selection, and maintenance of PPE and lifesaving equipment, including:

- Payment for protective equipment, 437-003-0134(4)
- Head protection, 437-003-0134(9)
- Eye and face protection, 437-003-0134(8)
- Respiratory protection, 1926.103
- Working over or near water, 1926.106
- Foot protection, 437-003-0134(10)

Head protection – Division 3, Subdivision E, 437-003-0134(9)

- Employees working in areas where there is a danger of head injury from impact, falling or flying objects, or electrical shock and burns must be protected by hard hats.
- Hard hats must meet the specifications contained in American National Standards Institute, Z89.1, Safety Requirements for Industrial Head Protection.

High-visibility garments – Division 3, Subdivision E, 437-003-0134(7)

Employees, other than flaggers, exposed to hazards caused by on-highway type moving vehicles in construction zones and highway traffic must wear highly visible upper body garments. The colors must contrast with other colors in the area to make the worker stand out. Colors equivalent to strong red, strong orange, strong yellow, strong yellow-green, or fluorescent versions of these colors are acceptable. During hours of darkness, the garments must also have reflective material visible from all sides for 1,000 feet.

Note: High visibility garments for **flaggers** must meet the requirements in Division 3, **Subdivision G**, 437-003-0420(2).

Personal protective equipment (PPE) – *continued*

Respiratory Protection – Division 3, Subdivision E, 1926.103

Construction work can certainly produce an assortment of harmful dust, gas, fumes, mist, smoke, and vapor. In order to protect your health, effective engineering and work practice controls such as ventilation, wet methods, and confinement of the task must be established. However, if these measures are not feasible, or not protective enough, appropriate respirators must be used.

When respirators are required, a written program must be implemented covering many important elements such as respirator selection procedures, fit testing for tight-fitting respirators, maintenance protocol, medical evaluations, and training. The employer must also designate a program administrator to oversee the respiratory protection program and conduct required evaluations. Please refer to 1926.103 (See Division 2, Subdivision I, 1910.134) for more details and consider consulting an industrial hygienist to help develop a program or review an existing one.

When it comes to PPE, do not forget other important factors such as proper selection, inspection, and training.

Qualified and competent persons

Requirements for qualified and competent persons are in several Oregon OSHA rules such as fall protection, scaffolding, steel erection, rigging, excavation, asbestos, and lead. The general definitions for "qualified" and "competent person" are in Division 3, Subdivision C, 1926.32:

- 1926.32(m) "Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his/her ability to solve or resolve problems related to the subject matter, the work, or the project.
- 1926.32(f) "Competent person" means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Division 3, Subdivision R (Steel erection) also adds the following: "In Oregon, a competent person is considered to be someone with equivalent skills as a qualified person in identifying existing and potential hazards in the workplace, while also being authorized by the employer or employer's representative to take immediate corrective action to control or eliminate hazards."

Excavations and rigging

Scaffolding

Asbestos

A competent person must be able to recognize hazards and have the authority to correct them.

Confined spaces

Rigging

Requirements for rigging equipment for material handling are in Division 3, Subdivision H, 1926.251, and include the following:

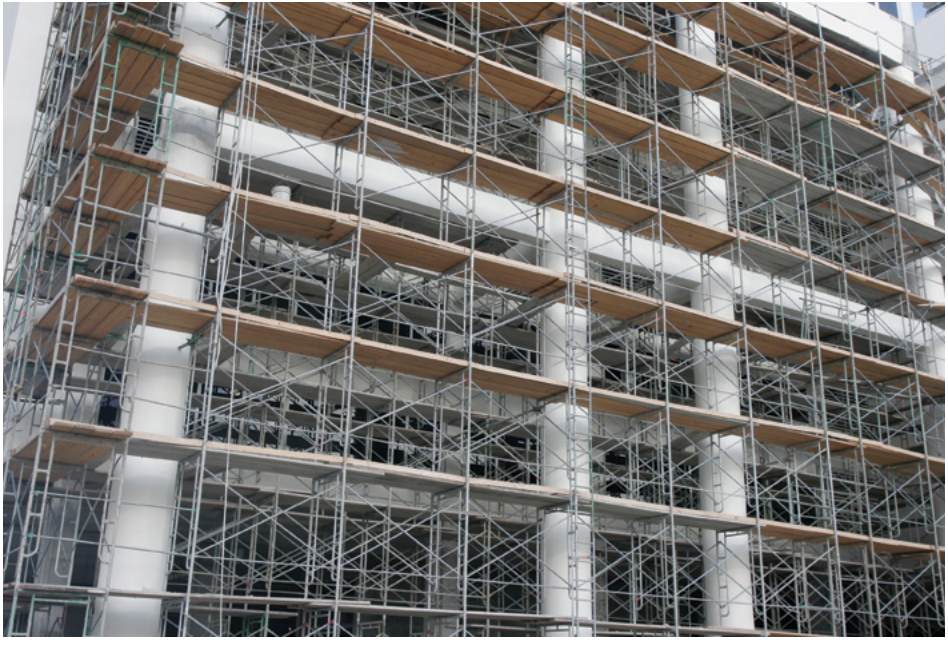
- Rigging equipment for material handling must be inspected before use on each shift and whenever necessary during its use to ensure that it is safe.
- Defective rigging equipment must be removed from service.
- Rigging equipment must not be loaded in excess of its recommended safe working load (See Division 3, Subdivision H Tables H-1 through H-20).
- Rigging equipment, when not in use, must be removed from the immediate work area so as not to present a hazard to employees.
- Custom-designed grabs, hooks, clamps, or other lifting accessories, for units such as modular panels, prefabricated structures, and similar materials, must be marked to indicate the safe working loads and must be proof-tested before use to 125 percent of their rated load. Included are alloy steel chain, wire rope, metal mesh, natural or synthetic fiber rope (conventional three strand construction), and synthetic web (nylon, polyester, and polypropylene).
- Each day before being used, slings and all fastenings and attachments must be inspected for damage or defects by a competent person designated by the employer (additional inspections must be performed when conditions warrant).

Scaffolding

Oregon OSHA's scaffolding requirements are covered in Division 3, Subdivision L, Scaffolding. Key sections include:

- Scope, application and definitions, 1926.450
- General requirements, 1926.451
- Additional requirements applicable to specific types of scaffolds, 1926.452
- Aerial lifts, 1926.453
- Training requirements, 1926.454

Oregon OSHA's scaffold standard includes provisions for both supported and suspended scaffolding, in addition to general requirements for capacity and platform construction, safe access, fall protection, falling object protection, safe use, and training. The standard also contains additional requirements for specific types of scaffolds.



Manually propelled elevating aerial platforms – Division 3, Subdivision L, 437-003-0071

When employees use manually propelled elevating aerial platforms as covered by ANSI/SIA A92.3-1990, the manufacturer's operating manual must be with the equipment. You must follow all operating and maintenance instructions and recommendations of the manufacturer.

Boom supported elevating work platforms – Division 3, Subdivision L, 437-003-0073

When employees use boom-supported elevating work platforms as covered by ANSI/SIA A92.5-1992, the manufacturer's operating manual must be with the equipment. Follow all operating and maintenance instructions and recommendations of the manufacturer.

Employees must use personal fall protection that complies with Division 3, Subdivision M, when working in these devices.

Scissor lifts – Division 3, Subdivision L, 437-003-0074

When employees use self-propelled elevating aerial platforms (scissor lifts) as covered by ANSI/SIA A92.6-1990, the manufacturer's operating manual must be with the equipment. Follow all operating and maintenance instructions and recommendations of the manufacturer.

Program directive A-242, Fall protection: aerial lifts used in construction

This Oregon OSHA program directive clarifies the requirement for fall protection when employees are using aerial lifts in construction.

Trenching and excavations

Oregon OSHA's requirements for excavation work are included in Division 3, Subdivision P, Excavations. Key sections include:

- Scope, application, and definitions, 1926.650
- Specific excavation requirements, 1926.651
- Underground installations, 437-003-0096
- Requirements for protective systems, 1926.652

Requirements covered in 1926.651 include:

- Surface encumbrances, 1926.651(a)
- Underground installations, 1926.651(b)
- Access and egress, 1926.651(c)
- Exposure to vehicular traffic, 1926.651(d)
- Exposure to falling loads, 1926.651(e)
- Warning system for mobile equipment, 1926.651(f)
- Hazardous atmospheres, 1926.651(g)
- Water accumulation, 1926.651(h)
- Stability of adjacent structures, 1926.651(i)
- Loose rock and soil, 1926.651(j)
- Daily inspections, 1926.651(k)
- Fall protection, 1926.651(l)

Excavation work can be incredibly hazardous. These workers face imminent danger. (OSHA)

Requirements covered in 1926.652 include:

- Protection of employees in excavations, 1926.652(a)
- Design of sloping and benching systems, 1926.652(b)
- Design of support systems, shield systems, and other protective systems, 1926.652(c)
- Materials and equipment, 1926.652(d)
- Installation and removal of support, 1926.652(e)
- Sloping and benching systems, 1926.652(f)
- Shield systems, 1926.652(g)

Each employee in an excavation must be protected from cave-ins by an adequate protective system except when excavations are made entirely in stable rock, or excavations are less than five feet deep and examination of the ground by a competent person provides no indication of a potential cave-in.

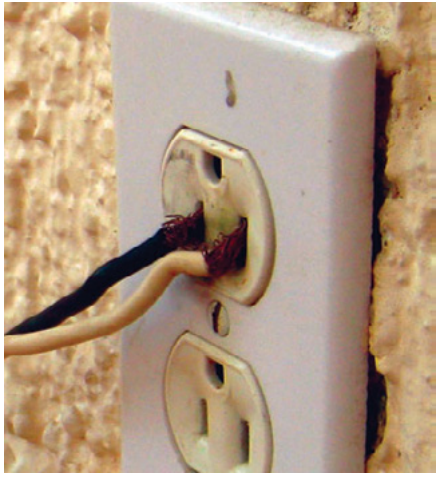
OSI Laborers' Skills Demonstration (October 2008)

Unsafe conditions and unsafe practices

Think of unsafe conditions and unsafe practices as hazards, because if they are not controlled they are likely to cause an injury or illness. Safety hazards cause injuries and health hazards cause illnesses.

Watch for unsafe conditions and unsafe practices; it is something that everyone can do on the job. Missing equipment guards, poorly maintained or defective equipment, and not following written safety procedures are examples. Require employees to report hazards immediately to someone who has authority to act on the report. Employees who report hazards need to be kept informed when and how the hazards will be controlled.

Also, look for new hazards whenever you change equipment, materials, or work processes, and determine how to control them.



Clockwise from top left: exposed conductors; no fall protection; no lower blade guard; and no fall protection, unstable, no safe access, etc.

Vehicles and mobile equipment

Oregon OSHA's requirements for vehicles and mobile equipment are in Division 3, Subdivision O, Motor Vehicles, Mechanized Equipment, and Marine Operations. Key parts of Subdivision O include:

- Equipment, 1926.600
- General requirements, 437-003-0085
- Pinch points, 437-003-0090
- Vehicle drivers and riders, 437-003-3224
- Vehicles for highway and road operation characteristics and maintenance, 437-003-3225
- Vehicles for use on property other than public roads and highways operation, characteristics and maintenance, 437-003-3226
- Material handling equipment (including earthmoving, excavating, and forklifts), 1926.602
- Personnel platforms on forklifts, 437-003-0094
- Pile driving equipment, 1926.603
- Site clearing, 1926.604
- Marine operations and equipment, 1926.605

Safe practices for operating vehicles:

- Do not allow employees to drive or ride in unsafe vehicles.
- Require employees to report any vehicle-related safety problems.
- Secure equipment and tools to prevent them from moving in a vehicle or make sure a barrier is in place to protect the passengers.
- Ensure that vehicles have working horns that can be heard above any surrounding noise.
- Any vehicle that has an obstructed view to the rear must have a backup alarm that can be heard above surrounding noise unless there is a spotter or it is certain that no one can enter the danger area.

Safe practices must be established and enforced when working around mobile equipment and vehicles.

Welding and cutting

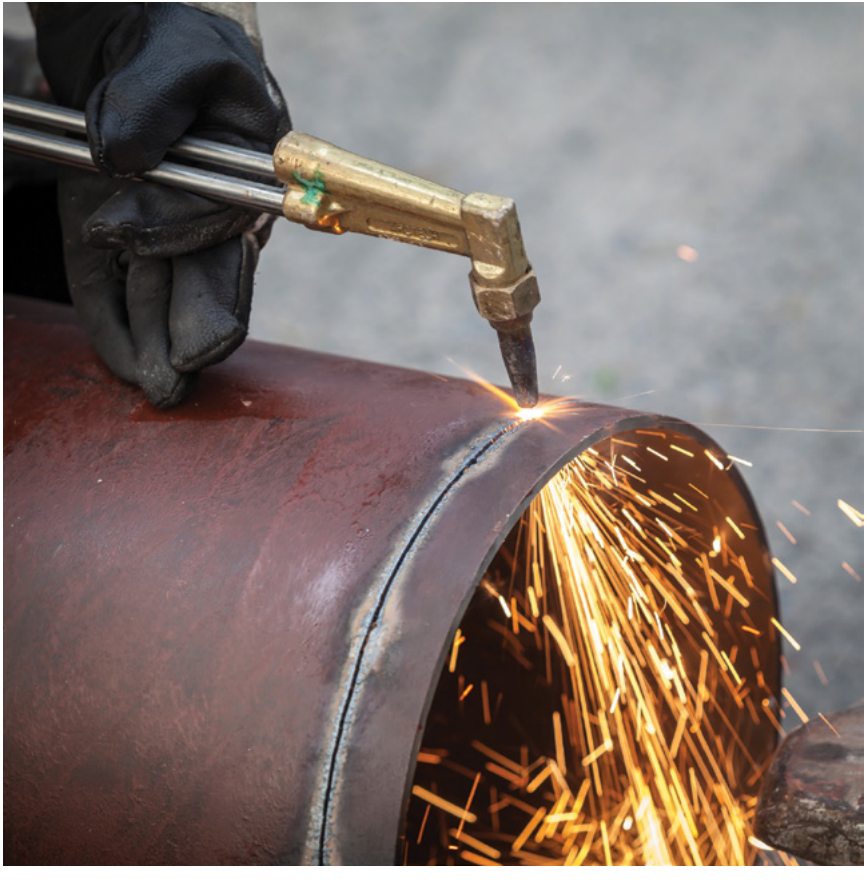
Oregon OSHA's welding requirements are in Division 3, Subdivision J, and include the following sections:

- Oxygen-fuel gas welding and cutting, 437-002-2253
- Arc welding and cutting, 1926.351
- Fire prevention, 1926.352
- Ventilation and protection in welding, cutting, and heating (includes confined spaces), 1926.353
- Welding, cutting, and heating in way of preservative coatings, 1926.354

Welding and cutting hazards include:

- Fire and explosion
- Chemical exposure, smoke, fumes, gas
- Burns (eye and skin)
- Noise
- Radiation
- Electric shock

Safe welding and cutting practices include ventilation, guards (screens and covers), and personal protective equipment (gloves, hood/helmet, eye and face protection, and respirators).



X-rays and other radiation

Oregon OSHA's radiation rules, in Division 3, Subdivision D, cover ionizing radiation and non-ionizing radiation.

Electromagnetic (EM) radiation

The most familiar form of electromagnetic (EM) radiation is sunshine, which provides light and heat. Sunshine consists primarily of radiation in infrared (IR), visible, and ultraviolet (UV) frequencies. Lasers also emit EM radiation in these "optical frequencies."

Ionizing radiation and non-ionizing radiation

The higher frequencies of EM radiation, consisting of X-rays and gamma rays, are types of ionizing radiation. Lower frequency radiation, consisting of ultraviolet (UV), infrared (IR), microwave (MW), radio frequency (RF), and extremely low frequency (ELF) are types of non-ionizing radiation. If not properly controlled, non-ionizing radiation, which is found in a wide range of occupational tasks including use of lasers and electric welding, can pose a health risk to potentially exposed employees.

Lasers

Laser stands for “Light Amplification by Stimulated Emission of Radiation.” The laser produces an intense, directional beam of light. The most common cause of laser-induced tissue damage is thermal in nature, where the tissue proteins are denatured due to the temperature rise following absorption of laser energy.

Because some lasers can damage eyes and skin:

- Only qualified, trained employees can install, adjust, and operate laser equipment.
- Laser equipment operators must be able to show proof that they are qualified when they are operating laser equipment.
- Employees who work in areas where potential exposure to laser light greater than five milliwatts exists, must be provided with anti-laser eye protection.
- Areas in which lasers are used must have laser warning signs.
- The laser beam must not be directed at employees.
- Laser equipment must have a label that indicates maximum output.

Your attitude

- Do you think accidents only happen to other people?
- Do you ignore unsafe situations because it is “not your job”?
- Do you think that an accident will not happen because it has never happened before?
- What if someone close to you was seriously injured in a workplace accident? Would this change your attitude towards safety?

Be aware of your attitude and how it affects others on the job. Do not wait for an accident to happen before you change your attitude towards safety.

Working within a culture that supports a positive attitude toward safety can do wonders to ensure safe construction sites. ***OSI Laborer’s Skills Demonstration (October 2008)***

Hoffman Construction Company

Over a third of all accepted disabling claims reported to the Oregon Workers' Compensation Division are sprains/strains and other musculoskeletal disorders. Although construction work will always include lifting, carrying, and pulling (among others), many contractors have made great strides in preventing these types of injuries through pre-task planning, employee involvement, medical management, and training their crews to recognize risk factors and best practices.

Zero energy state (lockout/tagout)

Lockout and tagging of electrical circuits – Division 3, Subdivision K, 1926.417

- Controls that are deactivated during work on equipment or circuits must be tagged
- Equipment or circuits that are de-energized must be inoperative and must have tags attached at all points where they can be energized
- Tags must be placed to identify plainly the equipment or circuits being worked on

The control of hazardous energy (lockout/tagout) – Division 2, Subdivision J, 1910.147(c)

Energy control program. The employer must establish a program consisting of energy control procedures, employee training, and periodic inspections. The purpose is to ensure that equipment is isolated from the energy source and made inoperative before any employee performs any service or maintenance where the unexpected energizing, start up, or release of stored energy could occur.

Energy control procedures must clearly outline the following steps for:

- Shutting down the equipment
- Isolating, blocking, and securing the equipment to control hazardous energy
- The placement, removal, and transfer of lockout/tagout devices and who is responsible for them
- The requirements for testing equipment to verify the effectiveness of lockout and tagout devices

Vehicles for highway and road operation characteristics and maintenance – Division 3, Subdivision O, 437-003-3225(8)

- Block or crib heavy equipment supported by slings, hoists, jacks; prevent the equipment from falling when employees work underneath it.
- During equipment repair or maintenance tasks set all controls to “neutral,” stop the motor, and set the brakes.
- During maintenance or inspection on vehicles with dump bins, use an attached, lockable support that prevents unintentional lowering of the bin.
- Disconnect the vehicle battery if the energized system could cause injury.

Dump-truck driver dies after being caught between frame and dump body of off-road truck while performing routine lubrication – Tennessee. ***NIOSH In-house FACE Report 2002-08.***

*Oregon*OSHA Services

Oregon OSHA offers a wide variety of safety and health services to employers and employees:

Appeals

503-947-7426; 800-922-2689; admin.web@oregon.gov

- Provides the opportunity for employers to hold informal meetings with Oregon OSHA on concerns about workplace safety and health.
- Discusses Oregon OSHA's requirements and clarifies workplace safety or health violations.
- Discusses abatement dates and negotiates settlement agreements to resolve disputed citations.

Conferences

503-378-3272; 888-292-5247, Option 1; oregon.conferences@oregon.gov

- Co-hosts conferences throughout Oregon that enable employees and employers to learn and share ideas with local and nationally recognized safety and health professionals.

Consultative Services

503-378-3272; 800-922-2689; consult.web@oregon.gov

- Offers no-cost, on-site safety and health assistance to help Oregon employers recognize and correct workplace safety and health problems.
- Provides consultations in the areas of safety, industrial hygiene, ergonomics, occupational safety and health programs, assistance to new businesses, the Safety and Health Achievement Recognition Program (SHARP), and the Voluntary Protection Program (VPP).

Enforcement

503-378-3272; 800-922-2689; enforce.web@oregon.gov

- Offers pre-job conferences for mobile employers in industries such as logging and construction.
- Inspects places of employment for occupational safety and health hazards and investigates workplace complaints and accidents.
- Provides abatement assistance to employers who have received citations and provides compliance and technical assistance by phone.

Public Education

503-947-7443; 888-292-5247, Option 2; ed.web@oregon.gov

- Provides workshops and materials covering management of basic safety and health programs, safety committees, accident investigation, technical topics, and job safety analysis.

Standards and Technical Resources

503-378-3272; 800-922-2689; tech.web@oregon.gov

- Develops, interprets, and gives technical advice on Oregon OSHA's safety and health rules.
- Publishes safe-practices guides, pamphlets, and other materials for employers and employees
- Manages the Oregon OSHA Resource Center, which offers safety videos, books, periodicals, and research assistance for employers and employees.

Need more information?

Call your nearest Oregon OSHA office.

Salem Central Office

350 Winter St. NE, Room 430
Salem, OR 97301-3882

Phone: 503-378-3272
Toll-free: 800-922-2689
Fax: 503-947-7461
en Español: 800-843-8086
Website: www.orosha.org

Bend

Red Oaks Square
1230 NE Third St., Suite A-115
Bend, OR 97701-4374
541-388-6066
Consultation: 541-388-6068

Eugene

1140 Willagillespie, Suite 42
Eugene, OR 97401-2101
541-686-7562
Consultation: 541-686-7913

Medford

1840 Barnett Road, Suite D
Medford, OR 97504-8250
541-776-6030
Consultation: 541-776-6016

Pendleton

200 SE Hailey Ave.
Pendleton, OR 97801-3056
541-276-9175
Consultation: 541-276-2353

Portland

16760 SW Upper Boones Ferry Road
Durham, OR 97224-7696
503-229-5910
Consultation: 503-229-6193

Salem

1340 Tandem Ave. NE, Suite 160
Salem, OR 97301
503-378-3274
Consultation: 503-373-7819

Oregon OSHA

A Division of the Department of Consumer and Business Services

440-4878 (R-1/17)

OR-OSHA

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	ACCIDENTS & SAFETY EMERGENCIES

- What is your plan for preventing damage, injury or loss in emergencies affecting the safety or protection of persons or the work or property at the site or adjacent areas?
- What is your plan for reporting all accidents involving lost work time or damaged CWS property to the CWS engineer/project manager? (Must be notified on the same workday the incident occurred.)
- What is your plan for notifying the CWS of any serious accidents or emergencies that occur during business hours, nights, weekends, and holidays?
- What is your plan for reporting to the CWS in writing if a claim is made by anyone against the contractor or any subcontractor on account of any accident?

Notes: _____

_____

❑ YES ❑ NO **ASBESTOS**

OAR 437-003-1926.1101, OAR 437-002-1910.1001

- Are employees properly trained and who is/are the competent person(s)?
- Are you prepared to post "Danger-Asbestos. Cancer and Lung Hazard. Keep Out" signs and have you identified where they need to be?
- When will the safety conference take place? *(Must include an CWS*
- representative, the contractor, the employer, and employees.)

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	CONFINED SPACE ENTRY

OAR 437-002-0146

- Is your confined space permit entry program at least as stringent as Oregon regulations and CWS procedures?
- What is your plan for notifying the CWS before entering a confined space?
- Do you have all necessary confined space entry and rescue equipment?
- Who will be permitted to enter confined spaces and use confined space equipment? Confirm that they are properly trained.
- How will you coordinate activities with the CWS, including emergency evacuation procedures, when working simultaneously in a permit space?
- Describe process for debriefing the CWS following entry operations to discuss hazards confronted or created during entry.

Notes: _____

_____

❑ YES ❑ NO — CONSTRUCTION ZONE TRAFFIC CONTROL

OAR 437-003-0420

- Does your traffic control system conform with the current MUTCD?
- Have you notified affected agencies (e.g., police, fire, ambulance, public works, bus and transit, etc) as needed?
- How and when will you inform occupants of abutting properties of access
- limitations made necessary by the work?
- Describe the installation & maintenance plan for the traffic control devices?
- Confirm that flaggers have been trained.
- Describe safeguards that will be used to protect workers and the general public (e.g., cones, flashing beacons, opening covers, etc.)
- Describe workers' visibility garments.
- Who will inspect the work site regularly to verify operation of safety devices?

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	CONTROL OF HAZARDOUS ENERGY (LOCKOUT/TAGOUT)

OAR 437, Division 2/J, 1910.147, 437-002-0154

- What is your plan for contacting the CWS about any work involving systems shutdown or startup?
- Describe the LOTO process that will be used, including:
- Identifying hazardous energy exposures
- De-energizing & re-energizing equipment
- Locking out, blocking and tagging energy sources
- Keying (only individual worker keying permitted)
- Re-energizing equipment

Notes: _____

_____

❑ YES ❑ NO	CRANE OPERATIONS

OAR 437, Division 3, Construction – Subdivision CC

- Do operators have the necessary certification, training and experience for cranes to be used?
- Have cranes and hoisting equipment been inspected and defects corrected?
- What is your planned inspection plan/routine for your cranes?
- Is rigging equipment well-maintained and identified properly as to capacity?
- Where will it be stored?
- Has a qualified signal person been identified for when the point of operation is not in full/direct view of the crane operator?
- Are cranes equipped with an audible, operator-controlled warning device?

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	ELECTRICAL WORK

OAR Chapter 437, Division 2/S, 437-002-0042

- Will electrical work meet Oregon regulations and the NEC? (required)
- How long will temporary installations be in place? (If one year or more, wiring and equipment shall be installed to conform to the Electrical Safety Orders for permanent installations.)
- What is your plan for implementing a Ground-Fault Circuit Protection program or an Assured Equipment Grounding Conductor program in accordance with Oregon regulations and the NEC?
- Describe your lockout/tagout program. Confirm that it is in accordance with Oregon OSHA regulations.

Notes: _____

_____

❑ YES ❑ NO	EMERGENCY ACTION PLAN

OAR Chapter 437, Division 2/S, 437-002-0042

- Describe your means of alerting employees to the need to evacuate in the event of an emergency requiring evacuation.
- Describe the means you will use to notify your employees to the need to evacuate.

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	EXCAVATION & TRENCHING

OAR 437, Division 3/P

- Will any excavation or trench that will be entered by workers be greater than 5 feet deep and is to be entered by workers? If so:
- Submit detailed plans of how workers will be protected from hazards. Have they been prepared and signed by a registered civil or structural
- engineer (required for excavations deeper than 20 feet).
- Identify (in writing) "Competent person(s)" and confirm that they will:
- Be on site at the beginning of each workday, frequently throughout the day and whenever a protective system is moved.
- Make daily excavation and protective system inspections.
- Is it possible that there will be any atmospheric hazard? What is your plan for atmospheric testing?
- Has any planned sloping or benching been designed by a registered civil engineer? (Required for excavations greater than 20 feet deep.)
- Confirm workers are trained in excavation safety and work site procedures.

Notes: _____

_____

❑ YES ❑ NO	WORKING AT ELEVATION (FALL FROM HEIGHT) HAZARDS

OAR 437, Division 2/D, 2/F, 2/I, 2/N

- Will employees work where is the potential to fall more than four feet for general industry activities or six feet for construction activities?
- Identify (in writing) "Competent person(s)" and confirm that they will be on site during activities that involve fall hazards.
- Confirm workers are trained trained in fall protection safety, their fall protection equipment and work site procedures.
- Do any fall protection systems require a qualified person?
- Have appropriate fall protection equipment inspections been completed?

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	**FIRE PREVENTION & PROTECTION** OAR 437, Division 2/L, 3/F • Describe how you will control fire hazards such as accumulation of combustibles, storage of flammables, hot work activities outsidedesignated hot work areas, etc. • What fire suppression and fire control equipment will you have on site? Notes: _____
❑ YES ❑ NO	**FIRST AID** OAR 437, Division 2/K, 3/C, 1926.23 • Describe your plans for addressing first aid and emergency medical situations • Will there be at least one CPR/First Aid trained employee on sitewhenever work is underway? Notes: _____
❑ YES ❑ NO	**HAZARD COMMUNICATION** OAR 437 Division 2/Z, 3/D, 4/Z • Will you have SDS's (MSDS) on site for any chemicals you bring on site? • How can CWS obtain the SDS for any chemical you bring on site? Notes: _____
❑ YES ❑ NO	**HAZARDOUS, FLAMMABLE, & TOXIC MATERIALS** OAR 437 Division 2/Z, 3/Z • Are you knowledgeable about, and in compliance with, all Federal, State, and Local hazardous materials laws, regulations, and ordinances? • Have you submitted a request for permission to bring hazardous substances on site? (Required if substances, if released, may significantly impact site • employees, contractor employees, general public, or the environment.) • What is your plan for promptly removing or properly disposing of hazardous waste once expired, no longer needed, or when the project is completed? • Have you planned to limit the amount of hazardous materials needed to perform the job? Notes: _____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	**HEAT ILLNESS HAZARDS** OAR 437-003-0015, OAR 437-001-0760(6), 1910.141(b)(1), 1926.51 • Describe your Heat Illness Prevention Plan including provisions for adequate water and shade for employees. • Have employees and supervisors been adequately trained? Notes: _____
❑ YES ❑ NO	**HOT WORK PERMITS** • Describe your hot work permitting process. (Note: A completed copy of the hot work permit must be posted in the immediate work area.) • Have employees been properly trained? • Have firewatchers been: • Identified? • Trained, including training on how to sound an alarm • Equipped with appropriate fire suppression equipment Note: Firewatchers must be stationed at the hot work area for at least 1/2 hour after the hot work activities are completed. Notes: _____
❑ YES ❑ NO	**HOUSEKEEPING/SANITATION** OAR 437 Division 3/C, 3/J, 1926.25, 1910.141 • Describe how you will manage housekeeping issues during the project. • Who would the CWS contact to have a housekeeping issue addressed? Notes: _____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	INDUSTRIAL TRUCK (FORKLIFT) HAZARDS

OAR 437, Division 2/N, 3/O, 4/N, 437-002-0227, 437-004-1700, 1910.178, 1926.602(c)

- Are operators current on their required training and certification?
- Are you providing your own forklift?
- Does it meet the design and construction regulations?
- Is the rated lifting capacity posted and readily visible to the operator?

Notes: _____

_____

❑ YES ❑ NO — LADDERS

OAR 437, Division 2/D, 1910.23, 437-002-0026

- Have employees been trained in safe ladder use?
- Have ladders been inspected frequently and free of damage and defects?
- Where will ladders be stored?
- Describe ladders to be used and confirm that they are appropriate to the work being performed.

Notes: _____

_____

❑ YES ❑ NO — LEAD EXPOSURES

OAR 437, Division 3/D, 1926.62

- Do all your procedures adhere to Oregon regulations?
- What is the plan for monitoring employee exposure and air monitoring data?
- What is your plan for dust containment for work activities that create significant levels of lead dust, nuisance dust, paint overspray, or any other environmental contamination that may adversely affect CWS employees and/or the public at large?

Notes: _____

_____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	PERSONAL PROTECTIVE EQUIPMENT OAR 437, Division 2/I, 3/E, 4/I • Remind contractor that they are responsible for all personal protective equipment and that they are not allowed to use any CWS personal protective equipment (i.e. gas meters, respirators, fall protection gear, etc). Notes: _____
❑ YES ❑ NO	RESPIRATORY PROTECTION PLAN OAR 437, Division 2/I, 1910.134 • Does your Plan cover training, respirator selection, medical evaluation, fit tests, use, cleaning, sanitizing, inspection, & maintenance? • Have you evaluated respiratory protection needs lead/ asbestos exposures? Notes: _____
❑ YES ❑ NO	SCAFFOLDING OAR 437, Division 3/L • Does scaffold design conform to design standards, or has it been designed by a licensed engineer? • Who is the Qualified Person that supervises scaffold erection &dismantling? • Where will scaffolds be located? Notes: _____
❑ YES ❑ NO	SIGNS & BARRICADES OAR 437, Division 3/G • Describe the signage and barricades that will be necessary for this project. • What is your plan for coordinating with the CWS and other agencies if aisles or roadways are to be blocked? • Will flashing beacon lights be used in conjunction with barricades atnight or in very dark work areas? Notes: _____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	WASTE DISPOSAL • Describe the plan to remove & dispose of debris, trash, & excavation spoils. • Describe your plan for removing hazardous materials, including hazardous wastes? (Hazardous materials/wastes must be removed by the contractor within 30 days after the completion of the project.) • Describe the plan for storing and labeling hazardous wastes and ensuring that they are not stored longer than the allowable accumulation times? Notes: _____

HAZARD REVIEW WORKSHEET *~Please Use Additional Sheets to Answer, As Necessary~*	
Response Required?	Topic
❑ YES ❑ NO	WELDING

OAR 437, Division 2/Q, 3/J, 4/Q

General Welding

- Has all welding equipment been inspected?
- Is an ABC-10+ pound, dry chemical extinguisher in the immediate area?
- Where will welding, cutting or burning activities be performed?
- What is your plan for inspecting work areas and ensuring that they are free of, or protected from, combustible materials?
- Describe your Hot Work Permit program, including firewatchers as needed.
- What is your plan for installing non-combustible barriers when welding in or over an elevated work area where combustible materials are present below?
- Have employees been given and trained on the use of appropriate PPE?
- What is your plan for ensuring adequate ventilation, either natural or mechanical in work areas?
- If welding is to be performed in confined spaces or enclosed buildings, what types of welders will be used and what is your plan for air testing and for
- ensuring proper ventilation?

Gas Welding

- Describe the labeling and storing plan for compressed gas cylinders.
- Where will the flammable gas storage area be located?
- Describe your plan for separating oxygen and flammable gases (e.g. acetylene) when not in use?
- Where will warning signs such as "No open flames" be posted?
- How will cylinders be transported?
- Have pressure reducing regulators, reverse flow check valves and flashback arresters been installed on the oxygen and acetylene hoses?

Arc Welding

- Will all power circuits be installed and maintained in accordance with applicable provisions of the most current National Electrical Code (NEC)?

Notes: _____

_____

SECTION 01330
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Wherever submittals are required in the Contract Documents, submit them to the Engineer.

B. All submittals shall be submitted electronically.

C. Electronic copies shall be in Microsoft Word, Excel, or Adobe PDF format unless otherwise specified. Electronic copies shall be submitted through a web-based construction management system (Procore Technology, Inc or other as identified). The Owner will provide access rights for the collaboration website to Contractor personnel as necessary. The Contractor will be required to utilize the collaboration website, including providing and utilizing necessary computers, internet services, phone services, and other office, scheduling, and communication software programs.

D. Definitions:

1. Action Submittal: Written and graphic information submitted by the Contractor that requires the Engineer's approval. (In general, all submittals are to be considered Action Submittals unless specifically indicated as informational or deferred submittals in the Contract Documents).
2. Deferred Submittal: Information required for the review of Contractor-designed systems that will be submitted to the local authority having jurisdiction for permitting.
3. Informational Submittals: Information submitted by the Contractor that does not require the Engineer's approval.

1.02 PRECONSTRUCTION CONFERENCE SUBMITTALS

A. At the preconstruction conference of Section 01110, Summary of Work, the Contractor shall submit the following items to the Engineer for review:

1. A preliminary list of Shop Drawings, Samples, and proposed Substitutes.
2. A preliminary schedule for submission of priority and major Shop Drawings (particularly for long-lead time equipment) and Samples.

3. A list of permits and licenses the Contractor shall obtain, indicating the agency required to grant the permit, the expected date of submittal for the permit, and required date for receipt of the permit.
4. A preliminary schedule of values in accordance with Section 01292, Schedule of Values.
5. A 60-Day Plan of Operation in accordance with Section 01324, Construction Schedule.
6. A Project Overview Gantt Chart in accordance with Section 01324, Construction Schedule.
7. Contractor's Project Specific Safety Plan and Hazard Assessment Worksheet in accordance with Section 01329, Safety Plan.

1.03 SHOP DRAWINGS

A. Wherever called for in the Contract Documents or where required by the Engineer, the Contractor shall furnish to the Engineer for review.

B. Shop Drawings in PDF format shall be bookmarked.

C. Shop Drawings may include detail design calculations, Shop-prepared Drawings, fabrication and installation drawings, erection drawings, lists, graphs, catalog sheets, data sheets, and similar items. If a list, graph, catalog sheet, data sheet, etc., includes more than one item, clearly mark which item is the subject of the submittal and the actual product to be furnished.

D. Shop Drawings that require Contractor to submit design calculations as part of a submittal, such calculations shall bear the signature and seal of an engineer registered in the appropriate branch and in the State of Oregon.

E. Shop Drawings in hard copy shall be accompanied by the Engineer's standard submittal transmittal form, a reproducible copy of which is available from the Engineer. A submittal without the form or where applicable items on the form are not completed will be returned for resubmittal.

F. Shop Drawing Organization:

1. A single submittal transmittal form shall be used for each technical specification section or item or class of material or equipment for which a submittal is required. A single submittal covering multiple sections will not be acceptable, unless the primary specification references other sections for components. Example: if a pump section references other sections for the motor, shop-applied protective coating, anchor bolts, local control panel, and variable frequency drive, a single submittal would be acceptable. A single submittal covering vertical turbine pumps and horizontal split case pumps would not be acceptable.

2. On the transmittal form, index the components of the submittal and insert tabs in the submittal to match the components. Relate the submittal components to specification paragraph and subparagraph, Drawing number, detail number, schedule title, room number, or building name, as applicable.
3. Unless indicated otherwise, terminology and equipment names and numbers used in submittals shall match those used in the Contract Documents.

G. Format:

1. Minimum sheet size shall be 8-1/2 inches by 11 inches. Maximum sheet size shall be 22 inches by 34 inches. Every page in a submittal shall be numbered in sequence. Each copy of a submittal shall be collated and stapled or bound, as appropriate. The Engineer will not collate sheets or copies.
2. Where product data from a manufacturer is submitted, clearly mark which model is proposed, with complete pertinent data capacities, dimensions, clearances, diagrams, controls, connections, anchorage, and supports. Sufficient level of detail shall be presented for assessment of compliance with the Contract Documents.
3. Each submittal shall be assigned a unique number based on the most relevant specification section number. Submittals shall be numbered sequentially, and the submittal numbers shall be clearly noted on the transmittal. Original submittals shall be assigned a numeric submittal number (e.g., 15200-1). If submittal “15200-1” requires a resubmittal, the first resubmittal will bear the designation “15200-1.1” and the second resubmittal will bear the designation “15200-1.2” and so on.
4. If there is a followup submittal related to a previously submitted class of material or type of equipment (e.g., follow-up submittal to submittal “15200-1”), it shall be assigned the next sequential number “15200-2.” If submittal “15200-2” requires a resubmittal, the first resubmittal will bear the designation “15200-2.1” and the second resubmittal will bear the designation “15200-2.1” and so on.

H. Shop Drawings that are unorganized, do not have a table of contents, do not clearly indicate what is submitted, and do not meet the requirements of the Contract Documents will be returned without review.

I. Except as may otherwise be indicated in sections, the Engineer will return submittal to the Contractor with comments noted thereon, within 21 days following receipt by the Engineer.

J. It is considered reasonable that the Contractor will make a complete and acceptable submittal to the Engineer by the third resubmittal on an item. Per General Conditions 7.16 E Resubmittal Procedures additional costs for the Engineer's review shall be the Contractors responsibility.

K. If a submittal is returned to the Contractor marked "NO EXCEPTIONS TAKEN," formal revision and resubmission will not be required.

L. If a submittal is returned marked "MAKE CORRECTIONS NOTED," Contractor shall make the corrections on the submittal, but formal revision and resubmission will not be required, but written acknowledgement that the corrections were made will be required and the final O&M manual will include both the written acknowledgment of the correction and the correction.

M. If a submittal is returned marked "AMEND-RESUBMIT," the Contractor shall revise it and shall resubmit the required number of copies to the Engineer for review. Resubmittal of portions of multi-page or multi-drawing submittals will not be allowed. For example, if a Shop Drawing submittal consisting of 10 drawings contains one drawing noted as "AMEND RESUBMIT," the submittal as a whole is deemed "AMEND RESUBMIT," and 10 drawings are required to be resubmitted.

N. If a submittal is returned marked "REJECTED-RESUBMIT," it shall mean either that the proposed material or product does not satisfy the specification, the submittal is so incomplete that it cannot be reviewed, or is a substitution request not submitted in accordance with the Contract Documents.

O. Resubmittal of rejected portions of a previous submittal will not be allowed. Every change from a submittal to a resubmittal or from a resubmittal to a subsequent resubmittal shall be identified and flagged on the resubmittal.

P. Fabrication of an item may commence only after the Engineer has reviewed the pertinent submittals and returned copies to the Contractor marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED." Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents and shall not be taken as changes to the Contract requirements.

Q. Submittals shall be carefully reviewed by an authorized representative of the Contractor prior to submission to the Engineer. Each submittal shall be dated and signed by the Contractor as being correct and in strict conformance with the Contract Documents. In the case of Shop Drawings, each sheet shall be so dated and signed. Any deviations from the Contract Documents shall be noted by the Contractor on the transmittal form and such deviation shall allowed if approved in writing by the Engineer and Owner. The Engineer will only review submittals that have been so verified by the Contractor. Nonverified

submittals will be returned to the Contractor without action taken by the Engineer, and any delays caused thereby shall be the total responsibility of the Contractor.

R. Corrections or comments made on the Contractor's Shop Drawings during review do not relieve the Contractor from compliance with Contract Documents. Review is for conformance to the design concept and general compliance with the Contract Documents only. The Contractor is responsible for confirming and correlating quantities and dimensions, fabrication processes and techniques, coordinating Work with the trades, and satisfactory and safe performance of the Work.

1.04 SAMPLES

A. The Contractor shall submit the number of samples indicated by the specification section. If the number is not indicated, submit not less than three samples. Where the amount of each sample is not indicated, submit such amount as necessary for proper examination and testing by the methods indicated.

B. Samples shall be individually and indelibly labeled or tagged, indicating the salient physical characteristics and manufacturer's name. Upon acceptance by the Engineer, one set of the samples will be stamped and dated by the Engineer and returned to the Contractor, one set of samples will be retained by the Engineer, and one set shall remain at the Site in the Engineer's field office until completion of the Work.

C. Unless indicated otherwise in specification section, the Engineer will select colors and textures from the manufacturer's standard colors and standard materials, products, or equipment lines. If certain samples represent nonstandard colors, materials, products, or equipment lines that will require an increase in Contract Times or Price, the Contractor shall clearly state so on the transmittal page of the submittal.

D. The Contractor shall schedule sample submittals such that:

1. Sample submittals for color and texture selection are complete so the Engineer has 45 days to assemble color panels and select color and texture dependent products and materials without delay to the construction schedule.
2. After the Engineer selects colors and textures, the Contractor has sufficient time to provide the products or materials without delay to the construction schedule. The Contract Times will not be extended for the Contractor's failure to allow enough review and approval or selection time, failure to submit complete samples requiring color or texture selection, or failure to submit complete or approvable samples.

1.05 TECHNICAL OPERATION AND MAINTENANCE INFORMATION

A. The Contractor shall submit technical operation and maintenance (O&M) information for each item of mechanical, electrical, and instrumentation equipment in an organized manner as specified in Section 01782, Operation and Maintenance Data, and in the specifications sections of the Contract Documents. O&M information, instructions and data shall be provided for each maintainable material and piece of equipment. It shall be written so that it can be used and understood by the Owner's operation and maintenance staff.

B. O&M Submittal Schedule: Except where indicated otherwise, technical O&M information shall be submitted in initial draft form to the Engineer not later than 90 days prior to any startup, system testing or operator training.

1. Subsequent drafts shall be provided by the Contractor within 30 days from the date of Contractor's receipt of review comments from the Engineer.
2. The approved Operation and Maintenance Manual must be available prior to any startup, system testing, or operator training.
3. The Contractor's attention is drawn to Section 01770, Closeout Procedures, where the submission of the Operation and Maintenance Manual is related to payments.

1.06 RECORD DOCUMENTS

A. The Contractor shall maintain one set of Drawings at the Site for the preparation of Record Drawings. On these, it shall mark every project condition, location, configuration, and any other change or deviation which may differ from the Drawings.

B. Buried or concealed construction and utility features shall be surveyed and located with coordinates recording the horizontal and vertical location of buried utilities regardless if they that differ from the locations indicated, or that were not indicated on the Drawings. Surveyed data shall be submitted to the Engineer on a monthly basis.

C. Record Drawings shall be supplemented by:

1. Any detailed sketches and pictures as necessary to fully indicate the Work as actually constructed.
2. Building Information Modeling (BIM).
3. Data files generated by the Contractor and incorporated into the Work:
    a. Point clouds (.rcs).
    b. AutoCAD (.dwg) files where no modeling occurs.

c. Coordination models.
d. Coordination drawings.

D. These Record Drawings are the Contractor's representation of as-built conditions, and shall be maintained up-to-date during the progress of the Work.

E. Using erasable colored pencils (not ink or indelible pencil), indicate in green when showing information deleted from the Drawings, red when showing information added to the Drawings, and blue and circled in blue to show notes.

F. Notes shall identify relevant Change Orders by number and date. Preparation of Record Drawings shall conform to the following:

1. Date entries.
2. Call attention to entry by "cloud" drawn around area or areas affected.
3. Legibly mark to record actual changes made during construction, including, but not limited to:
   a. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
   b. Horizontal and vertical locations of existing new underground facilities and appurtenances, and other underground structures, equipment, or Work. Reference to at least two measurements to permanent surface improvements.
   c. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
   d. Locate existing facilities, piping, equipment, and items critical to the interface between physical conditions or construction and new construction.
   e. Changes made by Addenda and Field Orders, Work Change Directives, Change Orders, Written Amendments, and Engineer's written interpretations and clarifications using consistent symbols for each and showing appropriate document tracking number.
4. Dimensions of Schematic Layouts: Show Record Drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.
   a. Clearly identify the item by accurate notation such as "cast iron drain," "galv. water," and the like.
   b. Show, by symbol or note, vertical location of item ("under slab," "in ceiling plenum," "exposed," and the like).
   c. Make identification so descriptive that it may be related reliably to Specifications.

G. The Contractor shall maintain one set of Specifications at the Site for the preparation of Record Specifications. On these shall be recorded every change or deviation during the course of the Project resulting from Work Change Directives, Field Orders, Substitutions, Engineer's written interpretation, and other reason. Record Specifications shall be marked with green, red and blue pencils in the same manner as Record Drawings, noting the document or other reason that caused the change.

H. Prior to submitting each Application for Payment, request Engineer's review and approval of current status of record documents. Failure to properly maintain, update, and submit record documents may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

I. In the case of those Drawings that depict the detail requirement for equipment to be assembled and wired in the factory, such as motor control centers and the like, the Record Drawings shall be updated by indicating those portions which are superseded by Change Order Drawings or final Shop Drawings, and by including appropriate reference information describing the change orders by number and the Shop Drawings by manufacturer, Drawing, and revision numbers.

J. Disorganized or incomplete record documents will not be accepted. The Contractor shall revise them and resubmit within 10 days.

K. Current as-built markups of record documents shall be accessible to the Engineer during the construction period and shall be provided to the Owner prior to requesting final payment. Current markups of electrical and instrumentation drawings shall be accessible to Owner during startup and until final Record Drawings are available.

L. The request for final payment will not be accepted until the record documents have been completed and delivered to the Engineer.

M. Information submitted by the Contractor will be assumed to be correct, and the Contractor shall be responsible for the accuracy of such information.

1.07 RECORD 3D LASER SCANNING

A. Perform high-definition 3D laser scan of the following buildings, interior spaces, including mechanical, electrical, and plumbing for as-built documentation.

B. Areas to be scanned:

1. Exterior and interior of Digester 3.

2. Exterior and interior of DC2 Control Building:
    a. DC2 Boiler Room.
    b. DC2 Basement (Pump Room).
    c. DC2 Electrical Room.
    d. DC2 Penthouse.

C. Level of Detail (LOD) and Accuracy: LOD 350, 1/4 -inch.

D. Data Registration and Processing:

1. Register all scanned data into a unified point cloud coordinate system.
2. Clean and process point clouds to remove noise and irrelevant data.

E. Deliverables:

1. Native point clouds (.rcs).
2. Registered and cleaned point clouds (.rcs).
3. Panoramic images.

1.08 QUALITY CONTROL (QC) SUBMITTALS

A. Quality control submittals are defined as those required by the Specifications to present documentary evidence to the Engineer that the Contractor has satisfied requirements of the Contract Documents.

B. Unless otherwise indicated, QC submittals shall be submitted:

1. Before delivery and unloading, for the following types of submittals:
    a. Manufacturers' installation instructions.
    b. Manufacturers' and Installers' experience qualifications.
    c. Ready mix concrete delivery tickets.
    d. Design calculations.
    e. Affidavits and manufacturers' certification of compliance with indicated product requirements.
    f. Laboratory analysis results.
    g. Factory test reports.
2. For the following types of submittals, the manufacturer's field representative shall submit a draft certification prior to leaving the Project Site and a final certification within 7 days of the event documented:
    a. Manufacturers' field representative certification of proper installation.
3. Within 30 days of the event documented for the following types of submittals:
    a. Field measurement.
    b. Field test reports.

c. Receipt of permit.
d. Receipt of regulatory approval.

4. Submittal and testing requirements as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. The Engineer will record the date that a QC submittal was received and review it for compliance with submittal requirements, but the review procedures above for Shop Drawings and samples will not apply.

1.09 INFORMATIONAL SUBMITTALS

A. Informational submittals formalize the flow of information between the Contractor and the Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01350
SPECIAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Special procedures for locating and verifying concealed existing facilities.

1.02 CONCEALED EXISTING FACILITIES

A. Verify locations of utilities and facilities which may exist by consulting with the Owner, utility companies, and Blue Stake or Underground Services Alert (USA) or other service available in area of Project.

1. Abide by easement and right-of-way restrictions.

B. Notify the Owner, owners of facilities when the Work will be in progress. Make arrangements for potential emergency repairs in accordance with requirements of owners of utility facilities, including individual or residential facilities.

C. Assume responsibility for repair of facilities damaged by performance of the Work.

D. Expose sanitary and storm sewers, water, gas, electric, telephone utility lines, and other underground facilities indicated to permit survey location prior to commencement of Work in affected area.

1. Expose in ample time to permit relocation of interfering utilities with minimum delaying effect on Contract Time.

E. Work required for raising, lowering, or relocating utilities not indicated will be performed by affected utility owners or as part of the Work at option of affected owners of utilities.

1. When part of the Work, perform work in accordance with standards of affected utility owner, and adjustment to Contract Price and Contract Times will be made as stipulated in conditions of Contract.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01352
ALTERATION PROJECT PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Requirements and procedures for performing alterations to existing facilities.

1.02 SUBMITTALS

A. Alterations Schedule: Submit in accordance with requirements for Progress Schedules.

1.03 SEQUENCE AND SCHEDULES

A. Perform Work in sequences and within times specified in Section 01140, Work Restrictions.

B. Submit separate detailed sub-schedule for alterations, coordinated with construction schedules. Indicate:

1. Each stage of Work and dates of occupancy of areas.
2. Date of Substantial Completion for each area of alterations as appropriate.
3. Trades and Subcontractors employed in each stage.

1.04 WORK INVOLVED WITH EXISTING OPERATING FACILITIES

A. Perform the Work while existing facility is in operation.

B. Do not jeopardize operation or materially reduce efficiency of existing facility.

C. Coordinate the Work with operation of the facility.

1. Do not begin alterations of designated portions of the Work until specific permission has been granted in writing by Owner in each case.
2. Engineer and Owner’s Construction Coordinator will coordinate the planned procedure with Owner’s operations and maintenance staff.
3. Complete as quickly as possible and with as little delay as possible, connections to existing equipment and utilities, and other operations that interfere with the operation of existing facility.

D. Operational functions of the facility that are required to be performed to facilitate the Work will be performed by facility personnel only.

E. Owner staff will cooperate in every way practicable to assist in expediting the Work.

F. When necessary for the proper operation or maintenance of portions of the facility, reschedule Work operations so that the Work will not conflict with necessary operations or maintenance of the facility.

1.05 ALTERATIONS, CUTTING, AND PROTECTION

A. Assign relocation, removal, cutting, and patching to trades qualified to perform in manner which causes least damage and provide means of returning surfaces to appearance of new construction.

B. Provide weather protection, waterproofing, heat and humidity control as needed to prevent damage to remaining existing and new construction.

C. Provide temporary enclosures as specified in Section 01500, Temporary Facilities and Controls, to separate construction areas from existing building and from areas occupied by Owner, and to provide weather protection.

1.06 SALVAGE SCHEDULE

A. Salvage Schedule:

1. Primary Heat Loop Pump 1: 725P6601.
2. Primary Heat Loop Pump 2: 725P6602.
3. Secondary Heat Loop Pump 1: 715P6601.
4. Secondary Heat Loop Pump 2: 715P6602.

1.07 PREPARATION

A. Identify existing materials that shall be patched, extended, or matched.

B. In addition to demolition specified and Construction specifically indicated on the Drawings, cut, move, or remove items as necessary to provide access or to allow alteration and new construction to proceed, including:

1. Repair or removal of hazardous or unsanitary conditions.
2. Removal of abandoned items and items serving no useful purpose, such as abandoned piping, conduit, and wiring.

3. Removal of unsuitable or extraneous materials not marked for salvage, such as abandoned furnishings and equipment, and debris such as rotted wood, rusted metals, and deteriorated concrete.
4. Cleaning of surfaces and removal of surface finishes needed to install new construction and finishes.
5. Disposal of items removed and not salvaged.

C. Cut and remove minimum amount of existing construction in manner which avoids damage to adjacent work.

D. Cut finish surfaces such as masonry, tile, plaster, and metals by methods which terminate surfaces in straight line at natural points of division.

E. Perform cutting and patching as specified in Section 01732, Cutting and Patching.

1.08 TRANSITION FROM EXISTING TO NEW WORK

A. When new construction abuts or finishes flush with existing construction, make smooth transitions and match architecture of existing construction.

B. Where partitions are removed, patch floors, walls, and ceilings with finish materials which match existing materials.

C. Where removal of partitions results in adjacent spaces becoming one, rework floors, walls, and ceilings to provide smooth planes without breaks, steps, or bulkheads.

D. Where changes of plane exceed 2 inches, request instructions for making transition.

E. Trim and refinish existing doors as necessary to clear new floors.

F. Match patched construction with adjacent construction in texture and appearance so that patch or transition is invisible at 5-foot distance.

G. When finished surfaces are cut so that smooth transition is impossible, terminate existing surface in neat manner along straight line at natural line of division and provide appropriate trim.

1.09 DAMAGED SURFACES

A. Patch and replace portions of existing finished surfaces which are damaged, lifted and discolored with matching material.

B. Provide adequate support of substrate prior to patching finishes.

C. Refinish patched portion of painted or coated surfaces in manner which produces uniform color and texture to entire surface.

D. When existing surface finish cannot be matched, refinish entire surface to nearest change of plane exceeding 45 degrees.

1.10 CLEANING

A. Perform periodic and final cleaning as specified in Section 01500, Temporary Facilities and Controls, and Section 01770, Closeout Procedures.

B. Clean Owner-occupied areas daily.

C. Clean spillage, overspray, and heavy collection of dust in Owner-occupied areas immediately.

D. At completion of each portion of Work, clean area and make surfaces ready for successive portions of Work.

E. At completion of alterations in each area, provide final cleaning and return space to condition suitable for use by Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01410
PERMITS AND REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The Contractor shall construct the Work in accordance with the Contract Documents and the referenced portions of those referenced codes, standards, and specifications.

B. References herein to “Building Code” or “Uniform Building Code” shall mean the International Building Code including State of Oregon Amendments. The latest edition of the code as adopted shall apply to the Work herein, including all addenda, modifications, amendments, or other lawful changes thereto.

C. In case of conflict between codes, reference standards, the Drawings, and the other Contract Documents, the most stringent requirements shall govern. All conflicts shall be brought to the attention of the Engineer for clarification and directions prior to ordering or providing any materials or furnishing labor. The Contractor shall bid for the most stringent requirements.

D. References herein to “OSHA Regulations for Construction” shall mean Title 29, Part 1926, Construction Safety and Health Regulations, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

E. References herein to “OSHA Standards” shall mean Title 29, Part 1910, Occupational Safety and Health Standards, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

F. Applicable Standard Specifications: References in the Contract Documents to “Standard Specifications” or SSPWC shall mean the Standard Specifications for Public Works Construction, 1997 Edition.

1.02 PERMITS

A. The Contractor shall keep fully informed of all local ordinances, as well as state and federal laws, which in any manner affect the Work. At all times the Contractor shall comply with said ordinances, laws, and regulations, and protect and indemnify the Owner and its officers and agents against any claim or liability arising from or based on the violation of such laws, ordinances, or regulations.

B. The Contractor shall abide by the conditions of all permits and shall obtain proof of satisfaction of conditions from issuers of permits prior to acceptance of the Work by the Owner.

C. The Contractor shall comply with all conditions attached to applicable local, state, and federal permits.

D. The Contractor is responsible for installation, maintenance, and discharge of all water from dewatering operations in accordance with all regulatory requirements.

E. The Owner has applied for, and has paid, or will pay for the required permits with the City of Tigard. The Contractor is responsible for obtaining the permits following completion of the Contractor's details within the appropriate sections of the permits. The Contractor shall abide by all regulations and conditions of the permits and shall obtain indications of acceptable satisfaction of conditions prior to acceptance of the Work by the Owner. Such regulations, conditions and requirements are made a part of these Specifications as fully and completely as though the same were fully set forth herein.

F. Contractor shall be responsible for acquiring and paying for any additional permits including a Right-of-Way (ROW) street closure permits.

G. ~~Permits and Easements Obtained After Bid Submittal: The Owner anticipates having all Owner obtained permits listed in the Supplementary Conditions by January 10, 2026. Relative to permitting, no claims for additional contract time, compensation, or otherwise shall be made by the Contractor prior to this date. If the Owner does not have all Owner obtained permits by January 10, 2026, the Contractor may request (by providing detailed backup and supporting documentation) additional non-compensable contract time for the Owner to review. If, after the Bid submittal date, the Owner obtains any permits or easements which require changes to the Work hereunder and thereby cause an increase or decrease in the cost of, or the time required for, the performance of the Work under this Contract, the Contractor shall submit information sufficient for the Owner's Representative to determine the extent of the effects on the cost and/or schedule. If the Owner's Representative agrees the cost and/or schedule will be affected by such changes, such effects will be handled in accordance with the General Conditions. The Owner's Representative will provide the Contractor with a copy of any such permits or easements. Comply with all applicable terms and conditions contained in such permits or easements.~~Permits and Easements Obtained After Bid Submittal: The Owner anticipates having all Owner obtained permits listed in the

Supplementary Conditions by February 13, 2026. Relative to permitting, no claims for additional contract time, compensation, or otherwise shall be made by the Contractor prior to this date. If the Owner does not have all Owner obtained permits by February 13, 2026, the Contractor may request (by providing detailed backup and supporting documentation) additional noncompensable contract time for the Owner to review. If, after the Bid submittal date, the Owner obtains any permits or easements which require changes to the Work hereunder and thereby cause an increase or decrease in the cost of, or the time required for, the performance of the Work under this Contract, the Contractor shall submit information sufficient for the Owner's Representative to determine the extent of the effects on the cost and/or schedule. If the Owner's Representative agrees the cost and/or schedule will be affected by such changes, such effects will be handled in accordance with the General Conditions. The Owner's Representative will provide the Contractor with a copy of any such permits or easements. Comply with all applicable terms and conditions contained in such permits or easements.[ADD. 6]

H. Posting Permits and Easements: Post permits and easements, as required, at the Site of the Work.

1.03 REGULATIONS RELATED TO HAZARDOUS MATERIALS

A. The Contractor shall be responsible that all Work included in the Contract Documents, regardless if shown or not, shall comply with all DEQ, EPA, OSHA, RCRA, NFPA, and any other federal, state, and local regulations governing the storage and conveyance of hazardous materials, including petroleum products. Also see Section 01560, Temporary Environmental Controls.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01424
ABBREVIATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Abbreviations and meanings.

1.02 INTERPRETATIONS

A. Interpret abbreviations by context in which abbreviations are used.

B. Wherever in these specifications references are made to the standards, specifications, or other published data of the various international, national, regional, or local organizations, such organizations may be referred to by their acronym or abbreviation only. As a guide to the user of these specifications, the following acronyms or abbreviations which may appear in these specifications shall have the meanings indicated herein.

1.03 ABBREVIATIONS

A. Abbreviations used to identify Reference Standards:

AA	Aluminum Association
AAMA	Architectural Aluminum Manufacturers Association
AAN	American Association of Nurserymen
AASHTO	American Association of State Highway and Transportation Officials
ABC	Associated Air Balance Council
ABPA	Acoustical and Board Products Association
ACI	American Concrete Institute
ACIL	American Council of Independent Laboratories
ADC	Air Diffusion Council
ABMA	American Bearing Manufacturers' Association (formerly AFBMA, Anti-Friction Bearing Manufacturers' Association)
AFBMA	Ant-Friction Bearing Manufacturer’s Association, Inc.
AFPA	American Forest Products Association
AGA	American Gas Association
AGC	Associated General Contractors
AGMA	American Gear Manufacturers' Association
AHA	American Hardboard Association
AHAM	Association of Home Appliance Manufacturers
AI	Asphalt Institute

AIA	American Institute of Architects
AIMA	Acoustical and Insulating Materials Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
APA	American Plywood Association
API	American Petroleum Institute
APWA	American Public Works Association
ARI	Air Conditioning and Refrigeration Institute
ASAHC	American Society of Architectural Hardware Consultants
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	ASTM International (Former name American Society for Testing and Materials. Still used in specifications.)
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWSC	American Welding Society Code
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Institute of America
BSI	Building Stone Institute
CLFMI	Chain Link Fence Manufacturers Institute
CPSC	U.S. Consumer Product Safety Commission
CRA	California Redwood Association
CRI	Carpet and Rug Institute
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards
CSI	Construction Specifications Institute
CTI	Ceramic Tile Institute
DHI	Door and Hardware Institute
EIFS	Exterior Insulation and Finish System
EJCDC	Engineers Joint Contract Documents Committee
FGMA	Flat Glass Marketing Association
FIA	Factory Insurance Association

FM	Factory Mutual
FS	Federal Specifications
FTI	Facing Tile Institute
GA	Gypsum Association
IAPMO	International Association of Plumbing and Mechanical Officials
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC	International Code Council
IEEE	Institute of Electrical and Electronics Engineers
MAG	Maricopa Association of Governments
MIA	Marble Institute of America
ML/SFA	Metal Lath/Steel Framing Association
MS	Military Specifications
NAAMM	National Association of Architectural Metal Manufacturers
NAPA	National Asphalt Pavement Association
NBHA	National Builders Hardware Association
NCMA	National Concrete Masonry Association
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NETA	International Electrical Testing Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NIST	National Institute of Standards and Technology
NMWIA	National Mineral Wood Insulation Association
NPCA	National Paint and Coatings Association
NRCA	National Roofing Contractors Association
NTMA	National Terrazzo and Mosaic Association
NWMA	National Woodwork Manufacturer's Association
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDCA	Paint and Decorating Contractors of America
PDI	Plumbing and Drainage Institute
PEI	Porcelain Enamel Institute
PS	Product Standard
RTI	Resilient Tile Institute

SAE	Society of Automotive Engineers
SCPA	Structural Clay Products Association
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Society for Protective Coatings-Steel Structures Painting Council
TCA	Tile Council of America
UBC	Uniform Building Code (ICBO)
UL	Underwriters Laboratories, Inc.
UNS	Unified Numbering System
USDA	United States Department of Agriculture
VA	Vermiculite Association
WCLA	West Coast Lumberman's Association
WCLIB	West Coast Lumber Inspection Bureau
WPA	Western Pine Association
WPOA	Western Plumbing Officials Association
WRC	Welding Research Council
WSCPA	Western States Clay Products Association
WWPA	Western Wood Products Association

B. Abbreviations used in these specifications:

a	year or years (metric unit)
A	ampere or amperes
am	ante meridian (before noon)
ac	alternating current
ac-ft	acre-foot or acre-feet
atm	atmosphere
AWG	American Wire Gauge
bbl	barrel or barrels
bd	board
bhp	brake horsepower
bil gal	billion gallons
BOD	biochemical oxygen demand
Btu	British thermal unit or units
Btuh	British thermal units per hour
bu	bushel or bushels

C	degrees Celsius
cal	calorie or calories
cap	capita
cd	candela or candelas
cfm	cubic feet per minute
Ci	curie or curies
cm	centimeter or centimeters
cmu	concrete masonry unit
CO	carbon monoxide
Co.	Company
CO_2	carbon dioxide
COD	chemical oxygen demand
Corp.	Corporation
counts/min	counts per minute
cu	cubic
cu cm	cubic centimeter or centimeters
cu ft	cubic foot or feet
cu ft/day	cubic feet per day
cu ft/hr	cubic feet per hour
cu ft/min	cubic feet per minute
cu ft/sec	cubic feet per second
cu in	cubic inch or inches
cu m	cubic meter or meters
cu yd	cubic yard or yards
d	day (metric units)
day	day (English units)
db	decibels
DB	dry bulb (temperature)
dc	direct current
diam	diameter
DO	dissolved oxygen
DS	dissolved solids
emf	electromotive force
fpm	feet per minute
F	degrees Fahrenheit
ft	feet or foot
fc	foot-candle or foot candles
ft/day	feet per day
ft/hr	feet per hour
ft/min	feet per minute
ft/sec	feet per second

g	gram or grams
G	gravitational force
gal	gallon or gallons
gal/day	gallons per day
gal/min	gallons per minutes
gal/sec	gallons per second
gfd	gallons per square foot per day
g/L	grams per liter
gpd	gallons per day
gpd/ac	gallons per day per acre
gpd/cap	gallons per day per capita
gpd/sq ft	gallons per day per square foot
gph	gallons per hour
gpm	gallons per minute
gps	gallons per second
h	hour or hours (metric units)
ha	hectare or hectares
HMI	human machine interface
hp	high point
hp	horsepower
hp-hr	horsepower-hour or horsepower-hours
hr	hour or hours (English units)
Hz	hertz
ID	inside diameter
ihp	indicated horsepower
Inc.	Incorporated
inch	inch
inches	inches
inches/sec	inches per second
J	joule or joules
JTU	Jackson turbidity unit or units
k	kips
K	kelvin
K	thermal conductivity
kcal	kilocalorie or kilocalories
kcmil	thousand circular mils
kg	kilogram or kilograms
km	kilometer or kilometers
kN	kilonewton or kilonewtons
kPa	kilopascal or kilopascals
ksi	kips per square inch

kV	kilovolt or kilovolts
kVA	kilovolt-ampere or kilovolt-amperes
kW	kilowatt or kilowatts
kWh	kilowatt hour
L	liter or liters
lb/1000 cu ft	pounds per thousand cubic foot
lb/acre-ft	pounds per acre-foot
lb/ac	pounds per acre
lb/cu ft	pounds per cubic foot
lb/day/cu ft	pounds per day per cubic foot
lb/day/acre	pounds per day per acre
lb/sq ft	pounds per square foot
lin	linear, lineal
lin ft	linear foot or feet
lm	lumen or lumens
log	logarithm (common)
ln	logarithm (natural)
lx	lux
m	meter or meters
M	molar (concentration)
mA	milliampere or milliamperes
max	maximum
mCi	millicurie or millicuries
meq	milliequivalent
μF	microfarad or microfarads
MFBM	thousand feet board measure
mfr	manufacturer
mg	milligram or milligrams
mgd/ac	million gallons per day per acre
mgd	million gallons per day
mg/L	milligrams per liter
μg/L	micrograms per liter
μm	micrometer or micrometers
mile	mile
mil. gal	million gallons
miles	miles
min	minimum
min	minute or minutes
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
mm	millimeter or millimeters
mol wt	molecular weight

mol	mole
Mpa	megapascal or megapascals
mph	miles per hour
MPN	most probable number
mR	milliroentgen or milliroentgens
Mrad	megarad or megarads
mV	millivolt or millivolts
MW	megawatt or megawatts
N	newton or newtons
N	normal (concentration)
No.	number
Nos	numbers
NRC	noise reduction coefficient
NTU or ntu	nephelometric turbidity unit
oc	on center
OD	outside diameter
ORP	oxidation-reduction potential
OT	ortho-tolidine
OTA	ortha-tolidine-arsenite
oz	ounce or ounces
oz/sq ft	ounces per square foot
Pa	pascal or pascals
pl	plate or property line
PLC	programmable logic controller
pm	post meridiem (afternoon)
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
pr	pair
psf/hr	pounds per square foot per hour
psf	pounds per square foot
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PVC	polyvinyl chloride
qt	quart or quarts
R	radius
R	roentgen or roentgens
rad	radiation absorbed dose
RH	relative humidity

rpm	revolutions per minute
rps	revolutions per second
s	second (metric units)
S	Siemens (mho)
SCADA	supervisory control and data acquisition
SDI	sludge density index or silt density index
sec	second (English units)
SI	International System of Units
sp	static pressure
sp gr	specific gravity
sp ht	specific heat
sq	square
cm^2 or sq cm	square centimeter or centimeters
sq ft	square feet or foot
sq inch	square inch
sq inches	square inches
km^2 or sq km	square kilometer or kilometers
m^2 or sq m	square meter or meters
mm^2 or sq mm	square millimeter or millimeters
sq yd	square yard or yards
SS	suspended solids
STC	Sound Transmission Class
SVI	sludge volume index
TDS	total dissolved solids
TFE	Tetrafluoroethylene
TKN	total Kjeldahl nitrogen
TLM	median tolerance limit
TOC	total organic carbon
TOD	total oxygen demand
TOW	top of weir
TS	total solids
TSS	total suspended solids
TVS	total volatile solids
U	U Factor/U Value
U	Coefficient of Heat Transfer
U	heat transfer coefficient
UNS	Uniform Numbering System
US	United States
V	volt or volts
VA	volt-ampere or volt-amperes

W	watt or watts
WB	wet bulb
wg	water gauge
wk	week or weeks
wt	weight
yd	yard or yards
yr	year or years (English unit)

C. Abbreviations used on the Drawings: As listed on the Drawings or in these specifications.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01450
QUALITY CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Specific quality control requirements for the Work are indicated throughout the Contract Documents. The requirements of this section are primarily related to performance of the Work beyond furnishing of manufactured products. The term “Quality Control” includes inspection, sampling and testing, and associated requirements.

B. The requirements of this section are in addition to those included as part of the Statement of Special Inspection Plan on the Drawings and Section 01451, Special Inspection, Observation, and Testing.

1.02 INSPECTION AT PLACE OF MANUFACTURE

A. The presence of the Engineer at the place of manufacture, however, shall not relieve the Contractor of the responsibility for providing products, materials, and equipment which comply with all requirements of the Contract Documents. Compliance is a duty of the Contractor, and said duty shall not be avoided by any act or omission on the part of the Engineer.

B. The Engineer and Owner, their assistants, inspectors, consultants and other employees of the Owner, shall at all times and for any purpose have access to the Work and the premises used by the Contractor, Subcontractors and Suppliers, and the Contractor, Subcontractors and Suppliers shall provide safe and proper facilities therefore. Furthermore, the Owner and the Engineer shall, at all times, have immediate access to all places of manufacture where machinery, equipment or materials are being manufactured, produced or fabricated for use under the Contract Documents, and shall have full facilities for determining that all such machinery, equipment or materials are being made strictly in accordance with the Contract Documents.

C. Contractor shall notify the Engineer and Owner in writing of testing to occur at the place of manufacture no less than 30 days before the test commence.

1.03 SAMPLING AND TESTING

A. Unless otherwise indicated, all sampling and testing will be in accordance with the methods prescribed in the current standards of the ASTM, as applicable to the class and nature of the article or materials considered; however, the Owner reserves the right to use any generally-accepted system of sampling and testing which, in the opinion of the Engineer will assure the Owner that the quality of the workmanship is in full accord with the Contract Documents.

B. Any waiver by the Owner of any specific testing or other quality assurance measures, whether or not such waiver is accompanied by a guarantee of substantial performance as a relief from the testing or other quality assurance requirements originally indicated, and whether or not such guarantee is accompanied by a performance bond to assure execution of any necessary corrective or remedial Work, shall not be construed as a waiver of any requirements of the Contract Documents.

C. Notwithstanding the existence of such waiver, the Engineer reserves the right to make independent investigations and tests, and failure of any portion of the Work to meet any of the requirements of the Contract Documents, shall be reasonable cause for the Engineer to require the removal or correction and reconstruction of any such Work in accordance with the General Conditions.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSTALLATION

A. Inspection: The Contractor shall inspect materials or equipment upon the arrival on the Job Site and immediately prior to installation and reject damaged and defective items.

B. Measurements: The Contractor shall verify measurements and dimensions of the Work, as an integral step of starting each installation.

C. Manufacturer’s Instructions: Where installations include manufactured products, the Contractor shall comply with manufacturer’s applicable instructions and recommendations for installation, to whatever extent these are more explicit or more stringent than applicable requirements indicated in Contract Documents.

END OF SECTION

SECTION 01451
SPECIAL INSPECTION, OBSERVATION, AND TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for Special Inspection, Observation, and Testing required in accordance with Chapter 17 of the 2021 IBC and is in addition to and supplements requirements included in Statement of Special Inspections shown on the Drawings.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7-16, Minimum Design Loads for Buildings and Other Structures.
2. International Code Council (ICC):
   a. International Building Code (IBC).
   b. Evaluation Service (ICC-ES) Reports and Legacy Reports.

1.03 DEFINITIONS

A. Agencies and Personnel:

1. Agency Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.
2. Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.
3. Registered Design Professional in Responsible Charge: An individual who is registered or licensed to practice their respective design profession as defined by statutory requirements of professional registration laws of state or jurisdiction in which Project is to be constructed.
4. Special Inspector: Qualified person employed by Owner who will demonstrate competence to the satisfaction of AHJ for inspection of a particular type of construction or operation requiring Special Inspection.

B. Statement of Special Inspections: Detailed written procedure contained on the Drawings establishing systems and components subject to Special Inspection, Observation, and Testing during construction, type and frequency of testing, extent and duration of Special Inspection, and reports to be completed and distributed by Special Inspector.

C. Special Inspection:

1. Special Inspection: Inspection required of materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved Contract Documents and referenced standards.
2. Special Inspection, Continuous: Full-time observation of work requiring Special Inspection by an approved Special Inspector who is present in area where the Work is being performed.
3. Special Inspection, Periodic: Part-time or intermittent observation of the Work requiring Special Inspection by an approved Special Inspector who is present in area where the Work has been or is being performed, and at completion of the Work.

D. Structural Systems and Components:

1. Diaphragm: Component of structural lateral load resisting system consisting of roof, floor, or other membrane or bracing system acting to transfer lateral forces to vertical resisting elements of structure.
2. Drag Strut or Collector: Component of structural lateral load resisting system consisting of a diaphragm or shear wall element that collects and transfers diaphragm shear forces to vertical force-resisting elements or distributes forces within diaphragm or shear wall.
3. Seismic-Force-Resisting System: That part of structural lateral load resisting system that has been considered in the design to provide required resistance to seismic forces identified on the Drawings.
4. Shear Wall: Component of structural lateral load resisting system consisting of a wall designed to resist lateral forces parallel to the plane of the wall. Unless noted otherwise on the Drawings, load-bearing walls with direct in-plane connections to roof and floors shall be considered to be shear walls.
5. Wind Force Resisting System: That part of the structural system that has been considered in the design to provide required resistance to wind forces identified on the Drawings.

E. Nonstructural Components:

1. Architectural Component Supports: Structural members or assemblies of members which transmit loads and forces from architectural systems or components to the structure, including braces, frames, struts, and attachments.
2. Electrical Component Supports: Structural members or assemblies which transmit loads and forces from electrical equipment to structure, including braces, frames, legs, pedestals, and tethers, as well as elements forged or cast as part of component for anchorage.
3. Mechanical and Plumbing Component Supports: Structural members or assemblies which transmit loads and forces from mechanical or plumbing equipment to structure, including braces, frames, skirts, legs, saddles, pedestals, snubbers, and tethers, as well as elements forged or cast as part of component for anchorage.

F. Professional Observation:

1. Does not include or waive responsibility for required Special Inspection or inspections by building official.
2. Requirements are indicated on Statement of Special Inspections (Plan) provided on the Drawings.
3. Geotechnical Observation: Visual observation of selected subgrade bearing surfaces by a registered design professional for general conformance to Contract Documents.
4. Structural Observation: Visual observation of structural system(s) by a registered design professional for general conformance to Contract Documents.
5. Statement of Special Inspections (Plan): Detailed written procedure contained on the Drawings establishing systems and components subject to Special Inspection, Observation, and Testing during construction, type and frequency of testing, extent and duration of Special Inspection, and reports to be completed and distributed by Special Inspector.

1.04 SUBMITTALS

A. Informational Submittals:

1. Contractor’s Statement of Responsibility: Form shall be completed by entity responsible for construction of main seismic-force-resisting system, listed in Statement of Special Inspections. Refer to Article Supplements, located at end of section.

1.05 STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS

A. Designated Systems for Inspection:

1. Seismic-force-resisting systems designated under IBC Section 1705 and subject to Special Inspection under Section 1707: See the Drawings for basic lateral load resisting systems for each structure and other designated seismic systems.
2. Wind-force-resisting systems designated under IBC Section 1706 and Section 1705. None required.
3. Architectural, Mechanical, and Electrical Components subject to Special Inspection and testing under IBC Section 1707 for Seismic Resistance: None required.

B. Statement of Special Inspections (Plan):

1. As included on the Drawings and in support of building permit application, Project-specific requirements were prepared by Registered Design Professional in Responsible Charge. The following identifies elements of inspection, observation, and testing program to be followed in construction of the Work:
   a. Designated seismic systems and main seismic force resisting systems and components that are subject to Special Inspection and Structural Observation for lateral load resistance.
   b. Special Inspection and testing required by IBC Section 1704 and Section 1708, and other applicable sections and referenced standards therein.
   c. Type and frequency of Special Inspection required.
   d. Type and frequency of testing required.
   e. Required frequency and distribution of testing and Special Inspection reports to be distributed by Special Inspector to Engineer, Contractor, building official, and Owner.
   f. Geotechnical Observation to be Performed: Not required for this Project.
   g. Structural Observations to be Performed: Required frequency and distribution of Structural Observation reports by registered design professional to Contractor, building official, and Owner. Special Inspection and associated testing of shop fabrication and field construction will be performed by an approved accredited independent agency or by Authority Having Jurisdiction’s (AHJ) approved, qualified inspection staff. Owner will secure and pay for services of agency to perform Special Inspection and associated testing.

C. Owner's plan for code required Special Inspection with associated testing, as provided in Statement of Special Inspections on the Drawings and further provided in this section, is for benefit of Owner and does not:

1. Relieve Contractor of responsibility for providing adequate quality control measures.
2. Relieve Contractor of responsibility for damage to or loss of material before acceptance.
3. Constitute or imply acceptance.
4. Affect continuing rights of Owner after acceptance of completed Work.

D. The presence or absence of code required Special Inspector does not relieve Contractor from Contract requirements.

E. Contractor is responsible for additional costs associated with Special Inspection and Testing when Work is not ready at time identified by Contractor and Special Inspectors are onsite, but not able to provide contracted services.

F. Contractor is responsible for associated costs for additional Special Inspection and Testing by Special Inspectors required because of rejection of materials of in place Work that cannot be made compliant to Contract Document without additional inspections and testing.

G. Contractor is responsible for associated costs for additional Special Inspection and Testing and Professional Observation by Special Inspectors and Professional Observers required due to rejection of materials of in place Work that cannot be made compliant to Contract Document without additional Site visits or testing.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Provide access to shop or Site for Special Inspection and Testing requirements.

B. Notify Engineer in advance of required Special Inspection no later than 48 hours prior to date of Special Inspection and Professional Observation.

C. Materials and systems, inclusive, shall be inspected during placement where Continuous Special Inspection is required.

D. Materials and systems shall be inspected during placement where Continuous Special Inspection is required.

1. Periodic Special Inspection shall be performed so that Work inspected after, but not during, its placement can be corrected prior to other related Work proceeding and covering inspected Work.
2. Periodic Special Inspection does not allow sampling of a portion of the Work. All Work shall be inspected.

3.02 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Contractor's Statement of Responsibility.

END OF SECTION

CONTRACTOR'S STATEMENT OF RESPONSIBILITY

_____
(Project)

_____
(Name of Contracting Company)

_____
(Business Address)

(_____) _____ (_____) _____
(Telephone) (Fax)

I, (We) hereby certify that I am (we are) aware of the Special Inspection and Testing and Professional Observation requirements contained in Contract Documents for this Project for seismic force-resisting systems as listed in Statement of Special Inspections (Plan) on the Drawings, and that:

1. I, (We) are responsible for implementation of the Statement of Special Inspections (Plan) for construction of the following systems:

Facility	**Lateral Force-Resisting System**
Structure Digester 3	Reinforced Concrete Tank

2. Control of this Work will be exercised to obtain conformance with Contract Documents approved by building official.

3. Procedures to be used for exercising control of the Work, the method and frequency of reporting, and distribution of reports required under the Statement of Special Inspections (Plan) for this Project are attached.

4. I, (We) will provide 48-hour notification to Engineer and approved agency as required for structural tests and Special Inspection for this Project.

5. The following person is hereby identified as exercising control over requirements of this section for the Work designated above:

Name: _____

Qualifications: _____

_____

_____

(Print name and official title of person signing this form)

Signed by: _____

Date: _____

Project Name: _____

SECTION 01500
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

1.02 GENERAL REQUIREMENTS

A. Types:

1. The types of utility services which may be required for general temporary use at the Site include the following:
   a. Water service (fire protection, potable for certain uses, and temporary hot water).
   b. Storm drain.
   c. Sanitary sewer.
   d. Electric power and lighting service.
   e. Internet service.
   f. Gas service.

1.03 JOB CONDITIONS

A. Scheduled Uses: The Contractor shall, in conjunction with establishment of job progress schedule, establish a schedule for implementation and termination of service for each temporary utility at the earliest feasible time, and when acceptable to Owner and Engineer, change over from use of temporary utility service to permanent service.

PART 2 PRODUCTS

2.01 MATERIALS

A. The Contractor shall provide either new or used materials and equipment, which are in substantially undamaged condition and without significant deterioration and which are recognized in the construction industry, by compliance with appropriate standards, as being suitable for intended use in each case. Where a portion of temporary utility is provided by utility company, the Contractor shall provide the remaining portion with matching and compatible materials and equipment and shall comply with recommendations of utility company.

2.02 FIELD OFFICES AND SHEDS

A. Contractor’s Field Office:

1. Maintain on Project Site weathertight space in which to keep copies of Contract Documents, progress schedule, Shop Drawings, and other relevant documents.
2. Provide field office with adequate space to examine documents, and provide lighting and internet service in that space.

B. Engineer’s Field Office:

1. Contractor shall provide a field office for exclusive use of Engineer and its representatives during construction. The field office shall be a minimum of 160 square feet. The field office shall be a weathertight space with adequate space to store and examine construction-related documents.
2. Field office shall include at a minimum the following:
   a. LED lighting and switches.
   b. Electrical outlets.
   c. Load center/breaker panel rated for 125 amps.
   d. Sliding windows.
   e. Electric heating and cooling.
   f. Internet access.
   g. One 30-inch by 60-inch desk.
   h. One 36-inch by 72-inch plan table.
   i. Two office chairs.
   j. Two folding chairs.
   k. Two waste baskets.
   l. Two tack boards.

m. One drinking water dispenser, bottled water unit with hot and cold spigots, refrigerated storage compartment, and cup dispenser. Maintain and replenish the bottled water and cup supply.
n. One 3-cubic foot to 6-cubic foot refrigerator.
o. One 1-cubic foot to 2-cubic foot microwave.
p. One copier/scanner/printer machine capable of processing up to 30 ppm, 1,200 dpi and 11-inch by 17-inch size color copies with reduction, collation, automatic feed, all required supplies, replenished and maintained.

2.03 CONSTRUCTION AIDS

A. Provide railings, kick plates, enclosures, safety devices, and controls required by Laws and Regulations and as required for adequate protection of life and property.

B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.

C. Design temporary supports with adequate safety factor to assure adequate load bearing capability.

1. When requested, submit design calculations by professional registered engineer prior to application of loads.
2. Submitted design calculations are for information and record purposes only.

D. Accident Prevention:

1. Exercise precautions throughout construction for protection of persons and property.
2. Observe safety provisions of applicable laws and regulations.
3. Guard machinery and equipment, and eliminate other hazards.
4. Make reports required Contract Documents, authorities having jurisdiction, and permit safety inspections of the Work.
5. Before commencing construction Work, take necessary action to comply with provisions for safety and accident prevention.

E. Barricades:

1. Place barriers at ends of excavations and along excavations to warn pedestrian and vehicular traffic of excavations. Barriers shall be a minimum 4-foot tall, orange construction fence with green steel fence T-posts. Where steel T-posts cannot be installed, provide 42-inch tall

portable delineator tubes with two rows of caution barricade tape strung between each delineator tube.
2. Provide barriers with flashing lights after dark.
3. Keep barriers in place until excavations are entirely backfilled and compacted.
4. Barricade excavations to prevent persons from entering excavated areas in streets, roadways, parking lots, treatment plants, or other public or private areas.

F. Warning Devices and Barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers.

1. Devices shall conform to minimum requirements of OSHA and state agency which administers OSHA regulations where Project is located.

G. Hazards in Public Right-of-Way:

1. Mark at reasonable intervals, trenches, and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours.
   a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.
2. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades.
   a. During hours of darkness, provide warning lights at close intervals.

H. Hazards in Protected Areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.

I. Above Grade Protection: On multi-level structures, provide safety protection that meets requirements of OSHA and State agency which administers OSHA regulations where Project is located.

J. Protect existing structures, trees, shrubs, and other items to be preserved on Project Site from injury, damage or destruction by vehicles, equipment, worker or other agents with substantial barricades or other devices commensurate with hazards.

K. Fences:

1. Enclose Site of the Work with fence adequate to protect the Work against acts of theft, violence, and vandalism, and to prevent staff from entering the Work area without appropriate PPE. Fences shall remain closed when no work is being performed.
2. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.
3. When entire or part of Site is to be permanently fenced, permanent fence may be built to serve for both permanent and temporary protection of the Work Site, provided that damaged or defaced fencing is replaced prior to Substantial Completion.
4. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons. Bear responsibility for protection of plant and material on Site of the work when openings in existing fences are not closed.
5. During night hours, weekends, holidays, and other times when no work is performed at Site, provide temporary closures or enlist services of security guards to protect temporary openings.
6. Temporary fencing at Site on driveway from 85th Street shall be used to prevent access in times when no work is performed at the Site, as the gate may be locked in the open position due to electrical outages.
7. Fence temporary openings when openings are no longer necessary.

2.04 SECURITY

A. Make adequate provision for protection of the Work area against fire, theft, and vandalism, and for protection of public against exposure to injury.

2.05 ACCESS ROADS

A. General:

1. Contractor shall access the Site from SW 85th Avenue and use the road north of the new digester.
2. Contractor and its subcontractors, vendors and visitors shall park on SW 85th Avenue when not actively being used for construction activities.
3. Contractor may use existing plant roads. All roads, except the road north of the new digester, must be kept in service and accessible by the Owner at all times.

4. Contractor shall construct a new access road for plant staff south of the new digester and north of the new decant facility.
5. Build and maintain dust free roads which are suitable for travel at 20 miles per hour.

B. Onsite Access Roads:

1. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
2. Maintain onsite access roads free of mud. Under no circumstances shall vehicles leaving the Site track mud off the Site onto the public right-of-way.

2.06 PROJECT CONSTRUCTION ENTRANCE SIGNS

A. Provide and maintain two Construction Entrance signs consisting of painted 8-foot wide by 4-foot high exterior grade plywood and minimum 10-foot long 4 by 4 lumber posts, set in ground at least 3 feet, with exhibit lettering by professional sign painter using no more than five sign colors.

1. Text Shall Indicate, at a Minimum: Construction access only.
2. Erect sign where directed by Owner or Engineer. Signs shall be erected at the north and south ends of SW 85th Avenue.

B. Provide a minimum of one additional sign to direct delivery and forces as required to the Project Site. Erect Project identification sign where directed by Owner or Engineer.

PART 3 EXECUTION

3.01 INSTALLATION OF TEMPORARY UTILITY SERVICES

A. General: Owner will provide Contractor access for temporary connection for the duration of the project. Contractor shall make and maintain temporary connection as required by the Owner.

B. Approval of Electrical Connections: Temporary connections for electricity shall be subject to approval of the Engineer and the Owner and shall be removed in like manner at the Contractor’s expense prior to final acceptance of the Work. Power connection to supply Contractor for temporary facilities requires the installation of a new 250-amp breaker in the existing 715MCC4401 cubicle at 8L.

C. Separation of Circuits: Unless otherwise permitted by the Engineer, circuits used for power purposes shall be separate from lighting circuits.

D. Construction Wiring: Wiring for temporary electric light and power shall be properly installed and maintained and shall be securely fastened in place. Electrical facilities shall conform to the requirements of Subpart K of the OSHA Safety and Health Standards for Construction.

3.02 INSTALLATION OF POWER DISTRIBUTION SYSTEM

A. Power: The Contractor shall provide and maintain all temporary power lines required to perform the Work in a safe and satisfactory manner. The Contractor shall pay for all costs for installation and removal of the temporary power service.

B. Temporary Power Distribution: Coordinate with Owner.

3.03 INSTALLATION OF LIGHTING

A. Construction Lighting: Work conducted at night or under conditions of deficient daylight shall be suitably lighted to ensure proper Work and to afford adequate facilities for inspection and safe working conditions.

B. Temporary Lighting: The Contractor shall provide a general, weatherproof, grounded temporary lighting system in every area of construction work, to provide sufficient illumination for safe work and traffic conditions. Run circuit wiring generally overhead, and rise vertically in locations where it will be least exposed to possible damage from construction operations on grade, floors, decks, or other areas of possible damage or abuse.

3.04 WATER SUPPLY

A. General: The Contractor shall provide an adequate supply of water of a quality suitable for all domestic and construction purposes.

B. The Contractor shall provide and operate all pumping facilities, pipelines, valves, hydrants, storage tanks, and all other equipment necessary for the adequate development and operation of the water supply system. Water used for domestic purposes shall be free of contamination and shall conform to the requirements of the State and local authorities for potable water. The Contractor shall be solely responsible for the adequate functioning of its water supply system and shall be solely liable for any claims arising from the use of same, including discharge or waste of water therefrom.

C. Water Connections: The Contractor shall not make connection to or draw water from any fire hydrant or pipeline without first obtaining permission of the authority having jurisdiction over the use of said fire hydrant or pipeline and from the agency owning the affected water system. For each such

connection made, the Contractor shall first attach to the fire hydrant or pipeline a valve and a meter, if required by the said authority, of a size and type acceptable to said authority and agency. The Contractor shall pay all permit and water charges.

D. Hot water is required at all times in the Brown Grease Receiving/O&M building. During heating water work, a temporary source of hot water will be required.

3.05 INSTALLATION OF SANITARY FACILITIES

A. Toilet Facilities: Fixed or portable chemical toilets shall be provided wherever needed for the use of Contractor's employees. Toilets at construction Job Sites shall conform to the requirements of Subpart D, Section 1926.51 of the OSHA Standards for Construction. All wastes and refuse from sanitary facilities provided by the Contractor or organic material wastes from any other source related to the Contractor's operations shall be disposed of away from the Site in a manner satisfactory to the Engineer and in accordance with all laws and regulations pertaining thereto. The Contractor shall provide and pay for all costs associated with any temporary sanitary service. Contractor shall not be permitted to utilize District sanitary facilities at the Site.

3.06 INSTALLATION OF FIRE PROTECTION

A. Fire Protection: The construction plant and all other parts of the Work shall be connected with the Contractor's temporary water supply system and shall be adequately protected against damage by fire. Hose connections and hose, water casks, chemical equipment, or other sufficient means shall be provided for fighting fires in the temporary structures and other portions of the Work, and responsible persons shall be designated and instructed in the operation of such fire apparatus so as to prevent or minimize the hazard of fire. The Contractor's fire protection program shall conform to the requirements of Subpart F of the OSHA Standards for Construction.

3.07 INSTALLATION OF GAS SERVICE

A. Gas Service: If desired by Contractor for heating, the Contractor shall install gas service and distribution piping of size adequate for temporary heating of enclosed construction Work, construction offices, toilets, fabrication shops and similar temporary facilities requiring heat.

3.08 INSTALLATION OF COMMUNICATIONS

A. Internet Services: The Contractor shall provide and maintain at all times during the progress of the Work at its own field construction office and Engineer's field construction office on the Site.

3.09 OPERATIONS AND TERMINATIONS

A. Inspections: Prior to placing temporary utility services into use, the Contractor shall inspect and test each service and arrange for governing authorities' required inspection and tests, and obtain required certifications and permits for use thereof.

B. Protection: The Contractor shall maintain distinct markers for underground lines, and protect from damage during excavating operations.

C. Termination and Removal: When need for a temporary utility service or a substantial portion thereof has ended, or when its service has been replaced by use of permanent services, or not later than time of substantial completion, the Contractor shall promptly remove installation unless requested by Engineer to retain it for a longer period. The Contractor shall complete and restore Work which may have been delayed or affected by installation and use of temporary utility, including repairs to construction and grades and restoration and cleaning of exposed surfaces.

D. Remove temporary buildings and furnishings before inspection for Final Completion or when directed.

E. Clean and repair damage caused by installation or use of temporary facilities.

F. Remove underground installations to minimum depth of 24 inches and grade to match surrounding conditions.

G. Restore existing facilities used during construction to specified or original condition.

END OF SECTION

SECTION 01505
MOBILIZATION

PART 1 GENERAL

1.01 SUMMARY

A. Mobilization shall include the obtaining of all permits; moving onto the Site of all plant and equipment; furnishing and erecting temporary buildings, and other construction facilities; and implementing security requirements; all as required for the proper performance and completion of the Work.

B. Mobilization shall include the following principal items:

1. Moving on to the Site of all Contractor’s equipment required for first month operations.
2. Installing temporary construction power, wiring, and lighting facilities.
3. Developing construction water supply.
4. Providing all onsite communication facilities.
5. Arranging for and erection of Contractor’s work and storage yard.
6. Obtaining all required permits.
7. Having all OSHA required notices and establishment of safety programs as identified in the Contractor’s Project Specific Safety Plan in accordance with Section 01329, Safety Plan.
8. Completion of the Clean Water Services Safety Orientation for Contractor and Subcontractor personnel per Section 01329, Safety Plan.
9. Having the Contractor's superintendent at the Job Site full time.
10. Submitting Preconstruction Conference Submittals in accordance with Section 01330, Submittal Procedures.

1.02 PAYMENT FOR MOBILIZATION

A. The Contractor’s attention is directed to the condition that 1 percent of the total Contract Price will be deducted from any money due the Contractor as progress payments until all mobilization items listed above have been completed as specified. The aforementioned amount will be retained by the Owner as the agreed, estimated value of completing all of the mobilization items listed. Any such retention of money for failure to complete all such mobilization items as a lump-sum item shall be in addition to the retention of any payments due to the Contractor as specified in Article 15 of the General Conditions of the Contract.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01530
PROTECTION OF EXISTING FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor shall protect all existing utilities and improvements not designated for removal and shall restore damaged or temporarily relocated utilities and improvements to a condition equal to or better than prior to such damage or temporary relocation, all in accordance with the Contract Documents.

B. Verify locations of utilities and facilities which may exist by consulting with the Contract Documents, Owner, Oregon811 (http://digsafelyoregon.com/) and locating service available in area of Project.

1.02 RESTORATION OF PAVEMENT, CURBS, SIDEWALKS, AND MOWSTRIPS

A. General: All paved areas including asphaltic concrete berms cut or damaged during construction shall be replaced with similar materials of equal thickness to match the existing adjacent undisturbed areas, except where specific resurfacing requirements have been called for in the Contract Documents or in the requirements of the agency issuing the permit. The pavement restoration requirement to match existing sections shall apply to all components of existing sections, including sub-base, base, and pavement. Temporary and permanent pavement shall conform to the requirements of the affected pavement owner. Pavements which are subject to partial removal shall be neatly saw cut in straight lines.

B. Temporary Resurfacing: Wherever required by the public authorities having jurisdiction, the Contractor shall place temporary surfacing promptly after backfilling and shall maintain such surfacing for the period of time fixed by said authorities before proceeding with the final restoration of improvements.

C. Permanent Resurfacing: In order to obtain a satisfactory junction with adjacent surfaces, the Contractor shall saw cut back and trim the edge so as to provide a clean, sound, vertical joint before permanent replacement of an excavated or damaged portion of pavement. Damaged edges of pavement along excavations and elsewhere shall be trimmed back by saw cutting in straight lines. All pavement restoration and other facilities restoration shall be constructed to finish grades compatible with adjacent undisturbed pavement.

D. Restoration of Curbs, Sidewalks, Mowstrips or Private Driveways: Wherever curbs, sidewalks, mowstrips or private roads have been removed for purposes of construction, the Contractor shall place suitable temporary curbs, sidewalks, mowstrips or private roads promptly after backfilling and shall maintain them in satisfactory condition for the period of time fixed by the authorities having jurisdiction over the affected portions. If no such period of time is so fixed, the Contractor shall maintain said temporary curbs, sidewalks, mowstrips or private roads until the final restoration thereof has been made.

1.03 EXISTING UTILITIES AND IMPROVEMENTS

A. General: The Contractor shall protect underground utilities and other improvements which may be impaired during construction operations, regardless of whether or not the utilities are indicated on the Drawings. The Contractor shall take all reasonable precautions for the protection of unforeseen utility lines to provide for uninterrupted service and to provide such special protection as may be necessary.

B. Except where the Drawings indicate utilities have been field located during design or certain utility locations shall be exposed as part of the Work, the Contractor shall perform exploratory excavations as it deems necessary to determine the exact locations and depths of utilities which may interfere with its work. All such exploratory excavations shall be performed as soon as practicable after Notice to Proceed and, in any event, a sufficient time in advance of construction to avoid possible delays to the Contractor’s progress. When such exploratory excavations show the utility location as shown on the Drawings to be in error, the Contractor shall so notify the Engineer.

C. The number of exploratory excavations required shall be that number which is sufficient to determine the alignment and grade of the utility.

D. Utilities to be Moved: In case it shall be necessary to move the property of any public utility or franchise holder, such utility company or franchise holder will, upon request of the Contractor, be notified by the Owner to move such property within a specified reasonable time. When utility lines that are to be removed are encountered within the area of operations, the Contractor shall notify the Engineer a sufficient time in advance for the necessary measures to be taken to prevent interruption of service.

E. Utilities to be Removed: Where the proper completion of the Work requires the temporary or permanent removal and/or relocation of an existing utility which is not indicated to be removed and/or relocated by the owner of the utility or other improvement which is indicated, the Contractor shall remove and, without unnecessary delay, temporarily replace or relocate such utility or improvement in a manner satisfactory to the Engineer and the owner of the facility. In all cases of such temporary removal or relocation, restoration to the former location shall be accomplished by the Contractor in a manner that will restore or replace the utility or improvement as nearly as possible to its former locations and to as good or better condition than found prior to removal.

F. Owner's Right of Access: The right is reserved to the Owner and to the owners of public utilities and franchises to enter at any time upon any public street, alley, right-of-way, or easement for the purpose of making changes in their property made necessary by the Work of this Contract.

G. Underground Utilities Indicated: Existing utility lines that are indicated or the locations of which are made known to the Contractor prior to excavation and that are to be retained, and all utility lines that are exposed or constructed during excavation operations shall be protected from damage during excavation and backfilling and, if damaged, shall be immediately repaired or replaced by the Contractor, unless otherwise repaired by the owner of the damaged utility. If the owner of the damaged facility performs its own repairs, the Contractor shall reimburse said owner for the costs of repair.

H. Costs of locating and repairing damage not due to failure of the Contractor to exercise reasonable care, and removing or relocating such utilities not indicated or not indicated with reasonable accuracy in the Contract Documents, and for equipment on the Project which was actually working on that portion of the Work which was interrupted or idled by removal or relocation of such utilities, and which was necessarily idled during such work will be paid for as extra Work in accordance with the provisions of the Contract Documents.

I. Approval of Repairs: All repairs to a damaged utility or improvement are subject to inspection and approval by an authorized representative of the utility or improvement owner before being concealed by backfill or other work.

J. Maintaining in Service: Unless indicated otherwise, oil and gasoline pipelines, power, and telephone or the communication cable ducts, gas and water mains, irrigation lines, sewer lines, storm drain lines, poles, and overhead power and communication wires and cables encountered along the line of the Work shall remain continuously in service during all the operations under the Contract, unless other arrangements satisfactory to the Engineer are made with the owner of said pipelines, duct, main, irrigation line, sewer, storm drain, pole, or wire or cable. The Contractor shall be responsible for and shall repair all damage due to its operations, and the provisions of this section shall not be abated even in the event such damage occurs after backfilling or is not discovered until after completion of the backfilling.

1.04 LAWN AREAS

A. Lawn and landscaped areas damaged during construction shall be repaired to match the pre-construction condition to the satisfaction of the Owner. Topsoil and compost shall meet the requirements specified in Section 02316, Fill and Backfill.

1.05 NOTIFICATION BY THE CONTRACTOR

A. Prior to any excavation in the vicinity of any existing underground facilities, including all water, sewer, storm drain, gas, petroleum products, or other pipelines; all buried electric power, communications, or television cables; all traffic signal and street lighting facilities; and all roadway and state highway rights-of-way, the Contractor shall notify the respective authorities representing the owners or agencies responsible for such facilities not less than 2 days prior to excavation so that a representative of said owners or agencies can be present during such work if they so desire.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01532
SITE CONDITIONS SURVEYS

PART 1 GENERAL

1.01 THE REQUIREMENTS

A. The Contractor shall conduct thorough preconstruction and post-construction Site conditions surveys of the entire Project in the company of the Owner and Engineer. Site conditions surveys shall consist of the following:

1. Photographs (.jpeg format).
2. Video (.mp4 format).

1.02 CONTRACTOR SUBMITTALS

A. Photographs, video, and other data of the preconstruction conditions shall be submitted to the Engineer for record purposes prior to, but not more than 3 weeks before, commencement of any construction activities.

B. A complete set of all photographs and survey data of the post-construction conditions shall be completed and submitted prior to final completion.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PHOTOGRAPHS AND VIDEO RECORDINGS

A. Contractor, as a minimum, shall document pre- and post-construction conditions by preparing videotape surveys of the following:

1. Roadways used to access the Work or haul materials and equipment around the Site.
2. Work areas, including actual work sites, materials processing and stockpiling areas, access corridors, and staging areas.
3. Any work completed by other contractors at the Site that will be connected to or otherwise affected by the Work.
4. Roads, curbs, driveways, sidewalks, and structures which might be affected by the Work.

B. Photographs shall be digital .jpeg format.

C. Video records shall be digital .mp4 format.

END OF SECTION

SECTION 01555
SITE ACCESS AND STORAGE

PART 1 GENERAL

1.01 HIGHWAY LIMITATIONS

A. The Contractor shall make its own investigation of the condition of available public and private roads and of clearances, restrictions, bridge load limits, and other limitations affecting transportation and ingress and egress to the Site of the Work. It shall be the Contractor's responsibility to construct and maintain any haul roads required for its construction operations.

1.02 TEMPORARY CROSSINGS

A. General: Continuous, unobstructed, safe, and adequate pedestrian and vehicular access shall be provided to fire hydrants, commercial and industrial establishments, churches, schools, parking lots, service stations, motels, fire and police stations, and hospitals. Safe and adequate public transportation stops and pedestrian crossings at intervals not exceeding 300 feet shall be provided. The Contractor shall cooperate with parties involved in the delivery of mail and removal of trash and garbage so as to maintain existing schedules for such services. Vehicular access to residential driveways shall be maintained to the property line except when necessary construction precludes such access for reasonable periods of time.

B. Temporary Bridges: Wherever necessary, to maintain vehicular crossings, the Contractor shall provide suitable temporary bridges or steel plates over unfilled excavations, except in such cases as the Contractor shall secure the written consent of the responsible individuals or authorities to omit such temporary bridges or steel plates, which written consent shall be delivered to the Engineer prior to excavation. All such bridges or steel plates shall be maintained in service until access is provided across the backfilled excavation. Temporary bridges or steel plates for street and highway crossing shall conform to the requirements of the authority having jurisdiction in each case, and the Contractor shall adopt designs furnished by said authority for such bridges or steel plates, or shall submit designs to said authority for approval, as may be required.

C. Street Use: Nothing herein shall be construed to entitle the Contractor to the exclusive use of any public street, alleyway, or parking area during the performance of the Work hereunder, and it shall conduct its operations to not interfere unnecessarily with the authorized work of utility companies or other agencies in such streets, alleyways, or parking areas. No street shall be closed to the public without first obtaining permission of the Engineer and proper governmental authority. Where excavation is being performed in primary streets or highways, one lane in each direction shall be kept open to traffic at all times unless otherwise indicated. Toe boards shall be provided to retain excavated material if required by the Engineer or the agency having jurisdiction over the street or highway. Fire hydrants on or adjacent to the Work shall be kept accessible to fire-fighting equipment at all times. Temporary provisions shall be made by the Contractor to assure the use of sidewalks and the proper functioning of all gutters, storm drain inlets, and other drainage facilities.

D. Contractor shall maintain public access to the RV Dump Facility. See Section 01140, Work Restrictions.

E. Contractor shall maintain access to the Septage Receiving Station. See Section 01140, Work Restrictions.

F. Contractor shall maintain access to the Headworks at all times. See Section 01140, Work Restrictions.

G. Contractor shall maintain access to the Brown Grease Receiving Facilities at all times. See Section 01140, Work Restrictions.

H. Contractor shall maintain access to Digester Complex 2 at all times. See Section 01140, Work Restrictions.

1.03 CONTRACTOR’S WORK AND STORAGE AREAS

A. The Owner will designate for the Contractor’s use, portions of the Site for its exclusive use during the term of the Contract. Contractor shall access the construction site from 85th Street. The gate may remain open during construction, provided temporary fencing is used to limit access when no work is being performed at the Site.

B. Lands to be furnished by the Owner for storage, staging, construction operation, roads and other purposes are indicated. Should the Contractor find it necessary to use any additional land for its operations or for other purposes

during the construction of the Work, it shall arrange for the use of such lands at its own expense and convenience.

1. Contractor may use the existing rock pad east of the new digester, and the area where the new decant facility will be constructed, including space to the west of the new decant facility. Areas shall be restored to existing conditions following use.

C. The Contractor shall construct and use a separate storage area for hazardous materials used in constructing the Work.

1. For the purpose of this paragraph, hazardous materials to be stored in the separate area are all products labeled with any of the following terms:
   a. Warning, Caution, Poisonous, Toxic, Flammable, Corrosive, Reactive, or Explosive. In addition, whether or not so labeled, the following materials shall be stored in the separate area: Diesel fuel, gasoline, new and used motor oil, hydraulic fluid, cement, paints and paint thinners, two-part epoxy coatings, sealants, asphaltic products, glues, solvents, wood preservatives, sand blast materials, and spill absorbent.
2. Hazardous materials shall be stored in groupings according to the Material Safety Data Sheets.
3. The Contractor shall develop and submit to the Engineer a plan for storing and disposing of the materials above.
4. The Contractor shall obtain and submit to the Engineer a single EPA number for wastes generated at the Site. Also comply with Article Hazardous Waste Disposal in Section 01560, Temporary Environmental Controls.
5. The separate storage area shall meet all the requirements of all authorities having jurisdiction over the storage of hazardous materials.
6. All hazardous materials which are delivered in containers shall be stored in the original containers until use. Hazardous materials which are delivered in bulk shall be stored in containers which meet the requirements of authorities having jurisdiction.

D. The Contractor shall construct and use a separate areas or constructed areas to complete the Work. The Contractor shall keep and maintain construction trailers onsite until Final Completion of the Project.

1.04 PARKING

A. The Contractor shall maintain traffic and parking areas in a sound condition, free of excavated material, construction equipment, mud, and construction

materials. The Contractor shall repair breaks, potholes, low areas which collect standing water, and other deficiencies.

B. Construction and personal vehicles may park on 85th Street, provided ingress and egress is not obstructed.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01560
TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 GENERAL

1.01 NOISE MITIGATION

A. The Contractor shall manage construction noise emanating from the Project Site to minimize impact to the adjacent neighbors.

B. The Contractor shall erect and maintain a temporary noise barrier or wall along the west fence and tree line of the Project Site.

C. The noise barrier shall be rated for sound transmission class STC-32 in accordance with ASTM E413 and be a minimum of 12 feet tall.

D. The noise barrier shall be free-standing and engineered to meet Site wind loading conditions, flame retardant, and UV resistant.

1.02 AIR POLLUTION CONTROL

A. Minimize air pollution from construction operations.

B. Burning of waste materials, rubbish, or other debris will not be permitted on or adjacent to the Site.

1.03 DUST ABATEMENT

A. The Contractor shall prevent its operation from producing dust in amounts causing a nuisance to persons living in or occupying buildings in the vicinity onsite.

B. The Contractor may use plant water for dust control but shall provide its own equipment to manage the water used or other dust abatement materials.

C. The Contractor shall not use waste oil or other similar materials that may cause damage to the environment for dust abatement.

D. The Contractor shall be responsible for any damage resulting from dust originating from its Work operations. This will include, but not limited to, the following:

1. Manufacturer’s authorized representative cleaning of Electrical MCCs, Switchgear, and Control Panels.

2. Manufacturer’s authorized representative cleaning VFDs, harmonic filters, and PLC control panels.
3. Manufacturer’s authorized representative cleaning turbo blower equipment and replacement of inlet filters.
4. Manufacturer’s authorized representative cleaning electrical motors
5. Manufacturer’s authorized representative replacement of HVAC filters.

E. The dust abatement measures shall be continued until the Contractor is relieved of further responsibility by the Engineer, or as soon as the need no longer exists.

F. Conduct operations of dumping rock and or carrying rock away in trucks to cause a minimum of dust. Give unpaved streets, roads, detours, or haul roads used in construction area a dust-preventative treatment or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust preventions.

G. Provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. Construct partitions of plywood, insulating board, plastic sheet, or similar material. Construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing building or facilities.

1.04 WATER POLLUTION CONTROL

A. Divert sanitary sewage and non-storm waste flow interfering with construction and requiring diversion to sanitary sewers. Do not cause or permit action to occur which would cause and overflow to existing waterway.

B. Prior to commencing excavation and construction, obtain Owner’s agreement with detailed plans showing procedures intended to handle and dispose of sewage, groundwater, and dewatering pump discharges.

C. Comply with Section 01570, Erosion and Sediment Control, for stormwater flow and surface runoff.

D. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

1.05 EROSION, SEDIMENT, AND FLOOD CONTROL

A. Provide, maintain, and operate temporary facilities as specified in Section 01570, Erosion and Sediment Control, to control erosion and sediment releases, and to protect the work and existing facilities from flooding during construction period.

1.06 RUBBISH CONTROL

A. During the progress of the Work, the Contractor shall keep the Site and other areas used by it in a neat and clean condition, and free from any accumulation of rubbish.

B. The Contractor shall dispose of all rubbish and waste materials of any nature occurring at the Site, and shall establish and maintain weekly intervals of collection and disposal of such materials and waste.

C. The District may request that the Contractor fully clean up the Site within a reasonable timeframe. If Contractor fails to clean up to the District's satisfaction by the agreed upon completion date, the District may do so and the cost of such clean up shall be charge back to the Contractor.

D. The Contractor shall also keep plant roads free from dirt, rubbish, and unnecessary obstructions resulting from its operations. Disposal of all rubbish and surplus materials shall be off the Site in accordance with local codes and ordinances governing locations and methods of disposal, and in conformance with all applicable safety laws, and to the particular requirements of Part 1926 of the OSHA Safety and Health Standards for Construction.

E. Contractor shall not use Owner's dumpsters or other rubbish containers unless specifically authorized.

1.07 CHEMICALS

A. All chemicals used during project construction or furnished for project operation, whether defoliant, soil sterilant, herbicide, pesticide, disinfectant, polymer, reactant or of other classification, shall show approval of either the U.S. Environmental Protection Agency or the U.S. Department of Agriculture. Use of all such chemicals and disposal of residues shall be in strict accordance with the printed instructions of the manufacturer.

1.08 HAZARDOUS WASTE DISPOSAL

A. It is the goal of the Owner to maintain category “Conditionally Exempt, Small Quantity Generator” regarding generation of Hazardous Waste. The pounds of waste generated by Contractor during construction activities shall be charged against the Contractor’s EPA ID number and not against the local site EPA ID number. This will require the Contractor to remove materials that meet Oregon’s definition of Hazardous Waste from Owner’s property as frequently as practical. Removal shall be done before consolidation, manifesting, or shipping of the waste, preferably by each workday’s end. Recycling or proper disposal of such waste shall be the responsibility of the Contractor or its agent.

1.09 EXPLOSIVES AND BLASTING

A. The use of explosives on the Work will not be permitted.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01570
EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 THE REQUIREMENTS

A. The purpose of erosion and sediment control is to improve water quality by reducing pollutants in stormwater discharges and soil erosion from the construction site. The Erosion and Sediment Control Plan (ESCP) has been prepared to meet requirements of the Department of Environmental Quality 1200-CN Permit and is detailed on the Drawings.

B. The Site is covered under the Owner's 1200-CN permit for erosion control. The contractor is responsible for implementing and maintaining all required erosion and sediment control measures per the approved plan. Any BMP deficiencies or site changes affecting erosion control must be addressed promptly and reported to the Owner.

C. The Contractor shall provide erosion control barriers, complete and in place, in accordance with the Contract Documents, the 1200-CN Permit requirements, and Chapter 6 of Clean Water Services' Design and Construction Standards (June 2007).

D. The Contractor shall provide erosion protection including fertilizing, seeding, and mulching for all disturbed areas, including stockpiled berms in accordance with the Contract Documents.

1.02 CONTRACT DOCUMENT SUBMITTALS

A. Contractor shall provide and identify an erosion control inspector and contact in an action plan to be submitted by the Owner.

B. Upon Award of Contract, Contractor shall assume all responsibilities for all sediment control.

C. Submittals shall be in accordance with Section 01330, Submittal Procedures.

PART 2 PRODUCTS

2.01 GENERAL

A. See Section 02370, Soil Stabilization.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01600
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 DEFINITIONS

A. The word “Products,” as used in the Contract Documents, is defined to include purchased items for incorporation into the Work, regardless of whether specifically purchased for the Project or taken from Contractor’s stock of previously purchased products. The word “Materials” is defined as products which must be substantially cut, shaped, worked, mixed, finished, refined, or otherwise fabricated, processed, installed, or applied to form Work. The word “Equipment” is defined as products with operational parts, regardless of whether motorized or manually operated, and particularly including products with service connections (wiring, piping, and other like items). Definitions in this paragraph are not intended to negate the meaning of other terms used in the Contract Documents, including “specialties,” “systems,” “structure,” “finishes,” “accessories,” “furnishings,” special construction,” and similar terms, which are self-explanatory and have recognized meanings in the construction industry.

B. Neither “Products” nor “Materials” nor “Equipment” includes machinery and equipment used for preparation, fabrication, conveying, and erection of the Work.

1.02 ANCHORAGE AND BRACING

A. The design of nonstructural products, materials, and equipment to be incorporated into the Work shall comply with the design and performance requirements specified in Section 01612, Anchorage and Bracing.

1.03 QUALITY ASSURANCE

A. Source Limitations: To the greatest extent possible for each unit of Work, the Contractor shall provide products, materials, and equipment of a singular generic kind from a single source.

B. Compatibility of Options: Where more than one choice is available as options for Contractor’s selection of a product, material, or equipment, the Contractor shall select an option which is compatible with other products, materials, or equipment. Compatibility is a basic general requirement of product, material, and equipment selections.

1.04 PRODUCT DELIVERY AND STORAGE

A. The Contractor shall deliver and store the Work in accordance with manufacturer's written recommendations and by methods and means which will prevent damage, deterioration, and loss including theft. Delivery schedules shall be controlled to minimize long-term storage of products at the Site and overcrowding of construction spaces. In particular, the Contractor shall ensure coordination to ensure minimum holding or storage times for flammable, hazardous, easily damaged, or sensitive materials to deterioration, theft, and other sources of loss.

1.05 TRANSPORTATION AND HANDLING

A. Products shall be transported by methods to avoid damage and shall be delivered in undamaged condition in manufacturer's unopened containers and packaging.

B. The Contractor shall provide equipment and personnel to handle products, materials, and equipment by methods to prevent soiling and damage.

C. The Contractor shall provide additional protection during handling to prevent marring and otherwise damaging products, packaging, and surrounding surfaces.

1.06 STORAGE AND PROTECTION

A. Products shall be stored in accordance with manufacturer's written instructions and with seals and labels intact and legible. Sensitive products shall be stored in weather-tight climate controlled enclosures and temperature and humidity ranges shall be maintained within tolerances required by manufacturer's recommendations.

B. For exterior storage of fabricated products, products shall be placed on sloped supports above ground. Products subject to deterioration shall be covered with impervious sheet covering and ventilation shall be provided to avoid condensation.

C. Loose granular materials shall be stored on solid flat surfaces in a well-drained area and shall be prevented from mixing with foreign matter.

D. Storage shall be arranged to provide access for inspection. The Contractor shall periodically inspect to assure products are undamaged and are continuously maintained under required conditions.

E. Storage shall be arranged in a manner to provide access for maintenance of stored items and for inspection.

1.07 MAINTENANCE OF PRODUCTS IN STORAGE

A. Stored products shall be periodically inspected on a scheduled basis. The Contractor shall maintain a log of inspections and shall make the log available on request.

B. The Contractor shall comply with manufacturer's product storage requirements and recommendations.

C. The Contractor shall maintain manufacturer-required environmental conditions continuously. This may require energizing panel and motor heaters or periodic rotation of gear train or motors. Contractor shall comply with maintenance intervals and provide power and conductors as required.

D. The Contractor shall ensure that surfaces of products exposed to the elements are not adversely affected and that weathering of finishes does not occur.

E. For mechanical and electrical equipment, the Contractor shall provide a copy of the manufacturer's service instructions with each item and the exterior of the package shall contain notice that instructions are included.

F. Products shall be serviced on a regularly scheduled basis, and a log of services shall be maintained and submitted as a record document prior to final acceptance by the Owner in accordance with the Contract Documents.

1.08 PROPOSED SUBSTITUTIONS

A. The procedure for review by the Engineer will be as set forth in the General Conditions and will include the following:

1. If the Contractor wishes to provide a substitution item, the Contractor shall make written application to the Engineer on the "Substitution Request Form."
2. Unless otherwise provided by law or authorized in writing by the Engineer, the "Substitution Request Form(s)" shall be submitted within a 35-day period after Notice to Proceed.
3. Wherever a proposed substitution item has not been submitted within said 35-day period, or wherever the submission of a proposed substitution material or equipment has been judged to be unacceptable by the Engineer, the Contractor shall provide the material or equipment indicated in the Contract Documents.
4. The Contractor shall certify by signing the form that the list of paragraphs on the form are correct for the proposed substitution.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01612
ANCHORAGE AND BRACING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for anchorage and bracing of equipment, distribution systems, and other nonstructural components required in accordance with the ICC 2021 International Building Code (IBC) as amended by the 2022 Oregon Structural Specialty Code (OSSC), for seismic, wind, gravity, soil, and operational loads.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Institute of Steel Construction (AISC): 360, Specification for Structural Steel Buildings.
2. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
3. International Code Council (ICC): International Building Code (IBC).
4. National Fire Protection Association (NFPA): 13, Standard for the Installation of Sprinkler Systems.
5. State of Oregon: 2022 Oregon Structural Specialty Code (OSSC).

1.03 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.

B. Designated Seismic System: Architectural, electrical, and mechanical system or their components for which component importance factor is greater than 1.0.

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

A. General:

1. Anchorage and bracing systems shall be designed by a qualified professional engineer registered in the State of Oregon.
2. Design anchorage into concrete including embedment in accordance with ACI 318-19, Chapter 17 (or other industry standard approved by Engineer), and Project Specifications.
3. Design anchorage and bracing of architectural, mechanical, and electrical components and systems in accordance with this section, unless a design is specifically provided within Contract Documents or where exempted hereinafter.
4. Design attachments, braces, and anchors for equipment, components, and distribution systems to structure for gravity, seismic, wind, and operational loading.
5. Design seismic anchorage and bracing for modified existing architectural, mechanical, or electrical systems where code requirements would dictate design for similar new components.
6. Piping and ductwork, whether exempt or not exempt for this section, shall be anchored and braced so that lateral or vertical displacement does not result in damage or failure to essential architectural, mechanical, or electrical equipment.
7. Architectural Components: Includes, but are not limited to, nonstructural walls and elements, partitions, cladding and veneer, access flooring, signs, cabinets, suspended ceilings, and glass in glazed curtain walls and partitions.
8. Provide supplementary framing where required to transfer anchorage and bracing loads to structure.
9. Adjust equipment pad sizes or provide additional anchorage confinement reinforcing to provide required anchorage capacities.
10. Design anchorage and bracing for:
    a. Equipment and components that weigh more than 400 pounds.
    b. Equipment weighing more than 20 pounds that has a center of mass located more than 4 feet above adjacent finished floor.
    c. Mechanical and electrical components that are not provided with flexible connections between components and associated ductwork, piping, or conduit.
    d. Distribution systems that weigh more than 5 pounds per foot that are mounted more than 4 feet above adjacent finished floor.

11. Design seismic anchorage and bracing for Designated Seismic Systems regardless of weight or mounting height.
    a. Component Important Factor:
        1) Ip equals 1, unless noted otherwise.
        2) Ip shall be taken as 1.5 if any of the following conditions apply:
            a) Component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems and egress stairways.
            b) Component contains hazardous materials.
            c) Component is in or attached to Risk Category IV structure and is needed for continued operation of facility or its failure could impair continued operation of facility.
12. For components exempted from design requirements of this section, provide bolted, welded, or otherwise positively fastened attachments to supporting structure.

B. Design Loads:

1. Gravity: Design anchorage and bracing for self-weight and superimposed loads on components and equipment.
2. Wind: Design anchorage and bracing for wind criteria provided on General Structural Notes on the Drawings for exposed architectural components and exterior and wind-exposed mechanical and electrical equipment. Alternately, manufacturer certification may be provided for components such as roofing and flashing to verify attachments meet Project-specific design criteria.
3. Operational:
    a. For loading supplied by equipment manufacturer for IBC required load cases.
    b. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), water hammer, and other load-inducing conditions.
    c. Locate braces to minimize vibration to or movement of structure.
    d. For vibrating loads, use anchors meeting requirements of Section 05500, Metal Fabrications, for anchors with designated capacities for vibratory loading per manufacturer’s ICC-ES report.
4. Hydraulic: Design of anchorage for submerged gates and other mechanical equipment shall include hydrostatic and hydrodynamic loads determined in accordance with Section 15.7 of ASCE 7-16.

5. Seismic:
    a. In accordance with 2021 IBC, Section 1613, and Chapter 13 of ASCE 7.
    b. Design anchorage and bracing for design criteria listed on General Structural Notes on the Drawings.
    c. Design forces for anchors in concrete or masonry shall be in accordance with ASCE 7, Section 13.4.2, or IBC Section 1905.1.9, as applicable for Project Seismic Design Category.

C. Seismic Design Requirements:

1. Nonstructural Components: Design as nonbuilding structures for components with weights greater than or equal to 25 percent of effective seismic weight of overall structure.
2. Analyze local region of body of nonstructural component for load transfer of anchorage attachment if component Ip equals 1.5.
3. The following are exempt from requirements for provision of seismic anchorages and bracing, in addition to those items specifically exempted in ASCE 7, Part 13.5 for architectural components and Part 13.6 for electrical and mechanical equipment:
    a. Furniture, except storage cabinets and bookshelves over 6 feet tall.
    b. Temporary or movable equipment.
4. Fire protection sprinkler systems designed and constructed in accordance with NFPA 13 shall be considered to meet requirements of Chapter 13 of ASCE 7.
5. Support drawings and calculations for electrical distribution components shall be provided if any of the following conditions apply:
    a. Ip is equal to 1.5 and conduit diameter is greater than 2.5-inch trade size.
    b. Ip is equal to 1.5 and the total weight of bus duct, cable tray, or conduit supported by trapeze assemblies exceeds 10 pounds per foot.
    c. Supports are cantilevered up from floor.
    d. Supports include bracing to limit deflection and are constructed as rigid welded frames.
    e. Attachments utilize spot welds, plug welds, or minimum size welds as defined by AISC.
6. Existing components, systems, and equipment in their final condition that are modified by Project requirements and are not exempted by above paragraph shall require same anchorage and bracing drawing and calculation submittals as new equipment. Field verify existing conditions.
7. Other seismic design and detailing requirements identified in ASCE 7, Chapter 13 are required to be provided for new and modified or noted

architectural, mechanical, and electrical components, systems, or equipment.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. List of architectural, mechanical, and electrical equipment requiring Contractor-designed anchorage and bracing, unless specifically exempted.
   b. Manufacturers' engineered seismic hardware product data.
   c. Seismic attachment assemblies' drawings; include connection hardware, braces, and anchors or anchor bolts for nonexempt components, equipment, and systems.
   d. List of existing architectural, mechanical, and electrical equipment or components to be modified in Project requiring Contractor-designed anchorage and bracing in final retrofitted condition.
   e. Seismic Attachment Assemblies' Drawings: Include connection hardware, braces, and anchors or anchor bolts for modified, nonexempt existing components, equipment, and systems where combination of new and existing systems or components' final condition would require anchorage or bracing under this specification for new equipment.
   f. Submittal will be rejected if proposed anchorage method would create an overstressed condition of supporting member. Revise anchorages and strengthening of structural support so there is no overstressed condition.

B. Informational Submittals:

1. Anchorage and Bracing Calculations: For attachments, braces, and anchorages, include IBC and Project-specific criteria as noted on General Structural Notes on the Drawings, in addition to manufacturer's specific criteria used for design; sealed by a civil or structural engineer registered in the State of Oregon.
2. Manufacturer's hardware installation requirements.

C. Deferred Submittals:

1. Submitted seismic anchorage drawings and calculations are identified as IBC deferred submittals and will be submitted to and accepted by AHJ prior to installation of component, equipment, or distribution system.
2. Submit deferred action submittals, such as Shop Drawings with supporting deferred informational submittals such as calculations no

less than 4 weeks in advance of installation of component, equipment, or distribution system to be anchored to structure.

1.06 SOURCE QUALITY CONTROL

A. Contractor and supplier responsibilities to accommodate Owner-furnished shop fabrication related special inspections and testing are provided in Project's Statement of Special Inspections on the Drawings and Section 01451, Special Inspection, Observation, and Testing.

B. All other specified, regulatory required, or repair verification inspection and testing that are not listed in Statement of Special Inspections, are to be provided by Contractor and shall meet requirements of Section 01450, Quality Control.

C. Source Quality Control shall be in accordance with Section 05500, Metal Fabrications.

PART 2 PRODUCTS

2.01 GENERAL

A. Attachments and supports transferring seismic loads to structure shall be designed and constructed of materials and products suitable for application and be in accordance with design criteria shown on the Drawings and nationally recognized standards.

B. Provide anchor bolts and concrete and masonry anchors for anchorage of equipment to concrete or masonry in accordance with Section 05500, Metal Fabrications. Size of anchor bolts and anchors, required minimum embedment, and spacing shall be based on calculations submitted by Contractor.

C. Do not use powder-actuated fasteners or sleeve anchors for seismic attachments and anchorage where resistance to tension loads is required. Do not use expansion anchors, other than undercut anchors, for nonvibration isolated mechanical equipment rated over 10 hp.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments, bracing, and anchorage in such a manner that component lateral force is transferred to lateral force resisting system of structure through a complete load path.

B. Overall seismic anchorage system shall provide restraint in all directions, including vertical, for each component or system so anchored.

C. Components mounted on vibration isolation systems shall have snubbers in each horizontal direction and vertical restraints where required to resist overturning.

D. Anchor piping in such a manner as to ensure piping system has adequate flexibility and expansion capabilities at flexible connections and expansion joints.

1. Piping and ductwork suspended more than 12 inches below supporting structure shall be braced for seismic effects to avoid significant bending of hangers and their attachments, unless high-deformability piping is used per ASCE 7, Section 13.6.8 or HVAC ducts have a cross-sectional area of less than 6 square feet.

E. Anchor tall and narrow equipment such as motor control centers and telemetry equipment at base and within 12 inches from top of equipment, unless approved otherwise by Engineer.

F. Do not attach architectural, mechanical, or electrical components to more than one element of a building structure at a single restraint location where such elements may respond differently during a seismic event. Do not make such attachments across building expansion and contraction joints.

G. Calculations shall limit anchor bolt concrete edge distance to a minimum of 4 inches or as required to provide sufficient anchor bolt capacity to resist the applied loads.

3.02 INSTALLATION

A. Do not install components or their anchorages or restraints prior to review and acceptance by Engineer and AHJ.

B. Notify Engineer upon completion of installation of seismic restraints in accordance with Section 01451, Special Inspection, Observation, and Testing.

3.03 FIELD QUALITY CONTROL

A. In accordance with Section 05500, Metal Fabrications.

B. Contractor responsibilities to accommodate Owner-furnished special inspections and testing are provided in Project’s Statement of Special Inspections on the Drawings and Section 01451, Special Inspection, Observation, and Testing.

C. Any other specified, regulatory required, or repair verification inspection and testing that are not listed in Statement of Special Inspections, are to be provided by Contractor and shall meet requirements of Section 01450, Quality Control.

END OF SECTION

SECTION 01640
MANUFACTURERS' SERVICES AND TRAINING

PART 1 GENERAL

1.01 DEFINITIONS

A. Person-Day: One person for 8 hours within regular Contractor working hours.

1.02 SUBMITTALS

A. Informational Submittals:

1. Training Schedule: Submit with Schedule of Values.
2. Lesson Plan: Submit with Equipment Submittals.
3. Trainer's Qualifications: Submit, with lesson plan, the resume of manufacturer's training representative demonstrating compliance with the experience requirements of these Specifications.

1.03 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified elsewhere.

B. Representative subject to acceptance by Owner and Engineer. No substitute representatives will be allowed unless prior written approval by such has been given.

1.04 EQUIPMENT REQUIRING MANUFACTURER'S SERVICES

A. Reference the equipment training matrix for equipment that requires manufacturer's services. This list may not be all-inclusive, and in no way relieves the Contractor or manufacturers of their duties required elsewhere in these Contract Documents.

B. Provide operations and maintenance training for mechanical, electrical and instrumentation equipment. Utilize manufacturer's representatives to conduct training sessions.

1.05 EQUIPMENT REQUIRING TRAINING

A. Reference the equipment training matrix for equipment that requires manufacturer's training. The list may not be all-inclusive, and in no way relieves the Contractor or manufacturers of their duties required elsewhere in these Contract Documents. Training days may be separated by multiple trips as required by Owner. Training days shall to be separated from commissioning and start up days.

1. Provide links to YouTube videos for step by step repairs.
2. Make available live video chats for questions.
3. See Equipment Training Matrix (to be completed as part of Project design).
   a. 01756-SUP-4, Training tab.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

A. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, the time required to perform the specified services shall be considered incidental.

B. Schedule manufacturer' services to avoid conflict with other onsite testing or other manufacturers' onsite services. General contractor is responsible for all scheduling with Owner.

C. Determine, before scheduling services, that all conditions necessary to allow successful testing have been met.

D. Only those days of service approved by Engineer will be credited to fulfill the specified minimum services.

E. When specified in individual specification sections, manufacturer's onsite services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.

3. Providing, on a daily basis, copies of all manufacturers' representatives field notes and data to Engineer.
4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.
5. Resolution of assembly or installation problems attributable to, or associated with, respective manufacturer's products and systems.
6. Submit written field report of all checks and activities.
7. Assistance during functional and performance testing, and facility startup and evaluation.
8. Training of Owner's personnel in the operation and maintenance of respective product as required.
9. Additional requirements may be specified elsewhere.
10. If training is considered unacceptable or incomplete in the opinion of the Owner, then training shall be repeated with another trainer.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. When specified in individual specification section, submit prior to shipment of product or material.

B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

C. Signed by product manufacturer certifying that product or material specified conforms to or exceeds specified. Attach supporting reference data, affidavits, and certifications as appropriate.

D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 EQUIPMENT SUPPLIER'S CERTIFICATE OF INSTALLATION

A. Equipment Supplier's Certificate of Installation form, a copy of which is included in Section 01756, Testing and Facility Startup, shall be completed and signed by the equipment manufacturer's representative.

B. Such form shall certify that the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to assure that the equipment is complete and operational.

3.04 TRAINING

A. General:

1. Furnish manufacturer's representatives for detailed classroom and hands-on in the field training to Owner's personnel on operation and maintenance of specified product (system, subsystem, and component) and as may be required in applicable Specifications.
2. Provide a copy of the Power Point file to the District to use for training purposes of new employees.
3. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Section 01782, Operation and Maintenance Data.
4. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
5. Owner may elect to video tape training sessions at Owner's cost. Contractor and all subcontractors and suppliers shall not object.
6. Satisfactorily complete functional testing before beginning operator training.
7. Owner shall have the current and correct equipment O&M manual before training, not just the training manual.
8. Training shall be a Power Point style presentation with hardbound copies provided to each student to follow along and take notes.

B. Training Schedule:

1. List specified equipment and systems that require training services and show:
   a. Respective manufacturer.
   b. Estimated dates for installation completion.
   c. Estimated training dates.
2. Allow for multiple sessions to cover several shifts.
3. Wednesday is the preferred training day, other days must be agreed upon 2 weeks prior.
   a. Operational training time is Wednesday at 2 p.m., unless other agreements are made.
4. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by manufacturer's representatives. Adjust schedule for interruptions in operability of equipment.
5. Provide 3 weeks' notice prior to training.

C. Prestartup Training:

1. Coordinate training sessions with Owner's operating personnel and manufacturer's representatives, and with submission of operation and maintenance manuals in accordance with Section 01782, Operation and Maintenance Data.
2. Complete at least 14 days prior to beginning of facility startup but after system is fully functional.

D. Post-startup Training: If required in these Specifications, furnish and coordinate training of Owner's operating personnel by respective manufacturer's representatives.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Outline of Training Session.
2. Training Matrix.

END OF SECTION

OUTLINE OF TRAINING SESSION

1.01 OUTLINE OF TRAINING SESSION

A. Definition of Training Session Objectives:

1. Describe the goal of training session in detail.
2. State estimated time required for each major section.

B. Lesson Plan:

1. When manufacturer or vendor training of Owner personnel is specified, prepare for each required course, containing the following minimum information:
   a. Title and objectives.
   b. Recommended types of attendees (e.g., managers, engineers, operators, maintenance).
   c. Course description and outline of course content in accordance with Supplement Outline of Training Session.
   d. Format (e.g., lecture, self-study, demonstration, hands on).
   e. Instruction materials and equipment requirements.
   f. Resumes of instructors providing the training.

C. Equipment Operation:

1. Describe equipment’s operating (process) function, including startup, shutdown, and normal operation.
2. Describe equipment’s fundamental operating principals and dynamics.
3. Identify equipment’s mechanical, electrical, and electronic components and features.
4. Identify all support equipment associated with the operation of subject equipment (i.e., instrumentation).

D. Safety Considerations: Identify and describe all safety considerations and procedures pertinent to the equipment or system provided (i.e., lockout or tagout procedures, protection from moving parts, etc.).

E. Detailed Component Description:

1. Identify and describe in detail each component’s function.
2. Where applicable, group related components into subsystems. Describe subsystem functions and their interaction with other subsystems.
3. Identify and describe in detail equipment safeties and control interlocks.

F. Equipment Preventive Maintenance (PM):

1. Describe PM inspection procedures required to:
   a. Perform an inspection of the equipment in operation.
   b. Spot potential trouble symptoms (anticipate breakdowns).
   c. Forecast maintenance requirements (predictive maintenance).
2. Define the recommended PM intervals for each component.
3. Provide a list of lubricant's and replacement parts that the owner should stock and limitations of all other recommended replacement parts with part numbers and where to order from.
   a. Note: CWS will meet with internal partners and order through stores procurement process.
4. Describe appropriate cleaning practices and recommended intervals.

G. Equipment Troubleshooting:

1. Define recommended systematic troubleshooting procedures.
2. Provide component-specific troubleshooting checklists.
3. Describe applicable equipment testing and diagnostic procedures to facilitate troubleshooting.
4. Provide clear and organized troubleshooting matrix for each item or system.

H. Equipment Corrective Maintenance:

1. Describe recommended equipment preparation requirements.
2. Identify and describe the use of any special tools required for maintenance of the equipment.
3. Describe component removal or installation and disassembly/assembly procedures.
4. Shall perform at least two "Hands On" in the field detailed explanations of common corrective maintenance repairs—the how and where on the installed equipment.
5. Describe recommended measuring instruments and procedures and provide instruction on interpreting alignment measurements, as appropriate.
6. Define recommended torquing, mounting, calibration, and/or alignment procedures and settings, as appropriate.
7. Describe recommended procedures to check or test equipment following a corrective repair.

END OF SUPPLEMENT

Clean Water Services - Equipment Training Matrix
Facility Durham
Project Name Durham Phase 6B Digester
Project Number 7203

Spec Section	Equipment Type	# of Sessions	Hours	# of Sessions	Hours	# of Sessions	Hours
		Maintenance		Operator		E&I	
11383	Digester Gas Safety Equipment	1	4	1	2	1	4
11385	Digester Mixer	1	4	1	1	1	4
15202	Process Valves and Operators (Actuators)					1	4
15500	Heating Boilers	1	4	1	1	1	8
15720	Air Handling Units	1	4	1	1	1	4
15730	Unitary Air-Conditioning Equipment	1	4	1	1	1	4
15900	Instrumentation and Control Devices for HVAC	1	4	1	1	1	4
16262	Variable Frequency Drives					1	8
17208	Level Measurement: Radar			1	1	1	4
17305	Flow Measurement: Thermal Mass			1	1	1	4
17310	Flow Measurement: Ultrasonic Time of Flight					1	4
17311	Flow Measurement: Ultrasonic Doppler Flowmeters					1	4

MONTH-2025
Training Preference Day and Time

Operations	Wednesdays at 2pm
Maintenance	Tuesday, Wednesday 7am - 2pm
Electrical & Instrumentation	Tuesday, Wednesday 7am - 2pm

SECTION 01732
CUTTING AND PATCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Cutting and patching existing and new construction.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 01600, Product Requirements.

1.02 SUBMITTALS

A. Submit in accordance with Section 01330, Submittal Procedures.

B. Cutting and Patching Plan:

1. Submit details of proposed construction before cutting and patching construction commences affecting:
   a. Work of Owner or of others.
   b. Structural integrity of element of Project.
2. Cutting and Patching Plan shall include the following:
   a. Identification of Work.
   b. Description of affected construction.
   c. Necessity for cutting, patching, alteration, or excavation.
   d. Description of proposed construction.
   e. Scope of cutting, core drilling, patching, alteration, or excavation.
   f. X-ray or ultrasonic investigation for identification and prevention of damage to unexposed electrical or control raceway and conductors.

PART 2 PRODUCTS

2.01 MATERIALS

A. Comply with specifications and standards for products involved.

PART 3 EXECUTION

3.01 PREPARATION

A. Provide adequate temporary support as necessary to ensure structural integrity of affected portion of Work.

B. Provide devices and methods to protect other portions of Project from damage and persons from injury.

C. Provide protection from elements for that portion of Project, which may be exposed by cutting and patching, and maintain excavations free from water.

3.02 CUTTING AND PATCHING

A. Provide x-ray or ultrasonic investigation prior to cutting or core drilling masonry or concrete to prevent damage to unexposed electrical or control raceway and conductors.

B. Cut, Fit, and Patch when required to:

1. Make several parts fit together properly.
2. Remove and replace construction not conforming to Contract Documents.
3. Remove samples of installed construction as specified for testing.
4. Provide routine penetrations of structural surfaces for installation of piping and electrical conduit.

C. Execute cutting and demolition by methods which will prevent damage and will provide proper surfaces to receive installation of repairs.

D. Openings in Existing Concrete and Masonry:

1. Create openings by:
   a. Saw cutting completely through concrete or masonry.
   b. Scoring edges of opening with saw to at least 1-inch depth on both surfaces (when accessible) and removing concrete or masonry by chipping.
2. Do not allow saw cuts to extend beyond limits of opening.
3. Make corners square and true by combination of core drilling and grinding or chipping.
4. Prevent debris from falling into adjacent tanks or channels in service or from damaging existing equipment and other facilities.

E. Sizing of Openings in Existing Concrete or Masonry:

1. Make openings sufficiently large to permit final alignment of pipe and fittings without deflections.
2. Allow adequate space for packing around pipes and conduit to ensure watertightness.

F. Grouting Pipes in Place:

1. Sandblast concrete surfaces and thoroughly clean sand and other foreign material from surfaces prior to placing grout.
2. Grout pipes, sleeves, castings, and conduits in place by pouring grout under a head of at least 4 inches. Vibrate grout into place. Completely fill the spaces occupied by pipes, sleeves, castings, and conduits.
3. Water cure the grout.

G. Connections to Existing Pipes:

1. Cut existing pipe square.
2. Properly prepare the ends for the connection indicated on the Drawings.
3. Repair any damage to existing lining and coating.

H. Rehabilitate all areas affected by removal of existing equipment, equipment pads and bases, piping, supports, electrical panels, electric devices, and conduits such that little or no evidence of the previous installation remains.

1. Fill areas in existing floors, walls, and ceilings from removed piping, conduit and fasteners with specified concrete repair materials and finish smooth to match surrounding surface.
2. Remove concrete bases for equipment and supports by:
    a. Saw cutting clean, straight lines with a depth equal to the concrete cover over reinforcement minus 1/2-inch below finished surface. Do not cut existing reinforcement on floors.
    b. Chip concrete within scored lines and cut exposed reinforcing steel and anchor bolts.
    c. Patch with specified concrete repair materials to match adjacent grade and finish.
3. Terminate abandoned piping and conduits with blind flanges, caps, or plugs.

I. Treat Existing Concrete Reinforcement as follows:

1. Where existing reinforcement is to remain, protect, clean, and extend into new concrete.
2. Where existing reinforcement is not to be retained, cut off as follows:
   a. Where new concrete joins existing concrete at the removal line, cut reinforcement flush with concrete surface at the removal line.
   b. Where concrete surface at the removal line is the finished surface, cut reinforcement 2 inches below the surface, paint ends with epoxy, and patch holes with dry pack nonshrink grout.

END OF SECTION

SECTION 01738
SELECTIVE DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Demolition of portions of structures.

1.02 SUBMITTALS

A. Shop Drawings Include:

1. Demolition methods of load bearing structures not indicated on the Drawings, signed and sealed by structural professional engineer registered in state where Project is located.
2. Method of removing embedded relics and antiques.

B. Submittals for Information Only:

1. Permits and notices authorizing demolition.
2. Certificates of severance of utility services.
3. Permit for transport and disposal of debris.
4. Demolition procedures and operational sequence.

C. Project Record Documents: Include locations of service lines and capped utilities.

1.03 REGULATORY REQUIREMENTS

A. Dispose of debris in accordance with governing regulatory agencies.

B. Comply with applicable air pollution control regulations.

C. Obtain permits for building demolition, transportation of debris to disposal site and dust control.

D. Refer to Section 01410, Permits and Regulatory Requirements, for Environmental Survey information.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Do not interfere with use of adjacent buildings. Maintain free and safe passage to and from adjacent buildings.

B. Prevent movement, settlement or collapse of structures (adjacent services, sidewalks, driveways and trees). Provide and place bracing or shoring. Assume liability for movement, settlement or collapse. Promptly repair damage.

C. Cease operations and notify Engineer immediately when safety of structure appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.

D. Provide, erect and maintain barricades, lighting, guard rails, and protective devices as required to protect building occupants, general public, workers, and adjoining property.

1.05 EXISTING SERVICES

A. Arrange and pay for capping and plugging utility services. Disconnect and stub off. Notify affected utility company in advance and obtain approval before starting demolition.

B. Place markers to indicate location of disconnected services.

1.06 MAINTAINING TRAFFIC

A. Do not close or obstruct roadways without permits.

B. Conduct operations with minimum interference to public or private roadways.

1.07 MATERIALS

A. Materials and equipment to be retained by Owner: Embedded relics and antiques such as cornerstones, cornerstone contents, commemorative plaques and tablets.

B. Materials and equipment to be re-installed where indicated on the Drawings.

C. Contractor shall furnish all materials, tools, equipment, devices, appurtenances, facilities and services required for performing selective demolition work.

D. Erect weatherproof closures for exterior openings. Maintain exit requirements.

E. Erect and maintain dustproof partitions as required to prevent spread of dust, fumes and smoke to other parts of building, including but not limited to all electrical gear. On completion, remove partitions and repair damaged surfaces to match adjacent surfaces.

F. Protect interior of building from rain and water damage.

G. Provide and maintain protective devices to prevent injury from falling objects.

H. Locate guard rails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.

I. Cause as little inconvenience to adjacent occupied building areas as possible.

J. Protect landscaping, bench marks and existing construction to remain from damage or displacement.

K. Carefully remove designated materials and equipment to be retained by Owner or re-installed. Deliver materials and equipment when and where directed by Engineer. Store and protect materials and equipment to be re-installed.

1.08 DEMOLITION

A. Demolish designated portions of structures and appurtenances in orderly and careful manner.

B. Assume possession of demolished materials, unless specified otherwise. Remove demolished materials from site at least weekly.

C. Prevent airborne dust. Use water or dust palliative when necessary. Provide and maintain hoses and connections to water main or hydrant.

D. Do not burn materials on site.

E. Immediately upon discovery, remove, and dispose of contaminated, vermin infested, or dangerous materials by safe means so as not to endanger health of workers and public.

F. Remove trees and shrubs within marked areas, clear undergrowth and dead plant material as specified in Section 02200, Site Clearing.

G. Backfill open pits and holes caused by demolition as specified in Section 02316, Fill and Backfill.

H. Rough grade areas affected by demolition.

I. Remove demolished materials, tools, and equipment upon completion of demolition.

J. Use of demolished concrete, free of rebar, organics, and other miscellaneous materials, is acceptable for use as backfill only where indicated on the Drawings. Concrete pieces shall be 6 inches or less in any dimension, and be placed and intermixed with granular material in such a manner as to eliminate voids.

1.09 REPAIR

A. Repair damage caused by demolition.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01756
TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 SUMMARY

A. This specification covers the implementation, review, and execution of the startup and commissioning of a newly installed or modified process components in a system.

1.02 REFERENCE SECTIONS

A. Division 01, General Requirements, through Division 17, Process Instrumentation and Controls.

1.03 DEFINITIONS

A. Facility Startup Plan:

1. Summary of shutdown requirements which are necessary to complete startup of new and modified equipment and systems.
2. Testing procedures for each component in the project and overall project system.
3. Step by step list detailing the startup sequence of all equipment testing, packaged equipment, vendor support, operations support (water, chemicals, product), and the startup phasing for towards ORT 2. Use Supplement Overall Startup Checklist, in this section.

B. Factory Acceptance Test (FAT):

1. A test or tests conducted on an equipment item, system or device at the place of fabrication by the manufacturer. Factory acceptance tests may be witnessed by the Owner when required in the equipment specifications.
2. Manufacturer will make corrections to the equipment as identified during the factory test prior to shipment.
3. Manufacturer submits a factory test report prior to shipping the equipment to the Project Site. The factory test report shall be part of the Facility Startup Plan document.

C. Operational Readiness Test (ORT):

1. Purpose of the ORT test shall demonstrate that the physical installation is completed and all continuity have been checked, and the system is ready for testing demonstration. Included, but not limited to, all instruments shall be field calibrated and receive final adjustments as part of ORT. Through circuit loop demonstration testing, the accuracy of all wiring shall be demonstrated as well as hardwired interlocks and alarms per the Control Loop Description.
2. There are two parts of the ORT. The ORT-1 and ORT-2 and its prerequisite are described herein.

D. Prerequisite to ORT-1:

1. Prepare ORT-1 Binder (for each piece of equipment within a unit process), see Supplement 3, Startup Binder.
   a. Approved Loop or circuit drawings, Control loop drawings, and Interconnect diagrams for standalone equipment.
   b. Field instrument calibration sheet for each instrument.
2. Submitted and approved preliminary equipment O&M manuals.
3. Submitted and approved startup testing plan.
4. Submitted and approved training outlines and training schedules for all required equipment.
5. Submit in writing that the following items have been completed:
   a. Equipment installation complete.
   b. Including wiring test and checks.
   c. Equipment tags installed.
   d. Wiring labels and conduit labeling installed.
6. Track Over All Startup Check List Excel file and Equipment Check List Tab, filled out completely and submitted to the Owner.
7. Submit manufacturer's check out services for all equipment. Add a reference to manufacturer's certification sheet. See this section, Supplement Equipment Supplier's Certificate of Proper Installation.
8. Submit a list of all spare parts and specialty tools for each specification section.
9. Provide a clear Nameplate photo for each piece of equipment. Save in Procore in Photos under the "Equipment Name Plate" folder. The equipment tag number shall be the file name or the "Information" of each photo.

E. ORT-1:

1. Checkout of all control loops and instruments for a complete system from field devices to PLC I/O.

2. End-to-end loop test from field devices and equipment to SCADA shall be performed. Verify wiring connections, landing of wire on correct terminal, labeling of conductors and conduits. Use calibrated testing equipment to simulate 4 mA to 20 mA signals to the PLC for each device and instrument.
3. Test variable frequency drives (VFD) and local control panels to ensure that all signals are in accordance with the control loop drawings, control loop descriptions, and are received correctly at the PLC. Verify all packaged equipment operates correctly with plant equipment and systems existing or new. Check that all the hardwired interlocks and alarm set points operate correctly.
   a. Power loss ride through.
   b. Communication loss.
4. Utilize loop drawings to thoroughly check each control loop, make red marks as needed.
5. Test and verify that control logic is properly operating for equipment start-up, shutdown, sequencing, interlocks and emergency shutdown.
6. Loop drawings shall be signed by all parties.

F. Prerequisite to ORT-2:

1. Completion of ORT-1, all forms signed off by Owner.
2. All equipment shall be available for operation. All manufacturer inspections and certifications completed.
3. Coordinate testing schedule with the Owner. Allow 14 days between the completion of ORT-1 and any scheduled ORT-2 testing.

G. ORT-2:

1. Programmers shall be given 7 working days to preform all ORT-2 programing checks.
2. System’s shall be left in the auto normal operating condition for programmer to fully test.
3. Test each control function and operating condition. End-to-end loop test from field devices and equipment to the SCADA HMI shall be performed. Test shall be performed using actual equipment and conditions with a minimum of simulated conditions. Set points, time delay and tuning constants shall be adjusted as part of this testing. Check out which includes, but is not limited to, testing of applications software developed by the Owner integrating individual components into a functioning system.
4. If portions of the Contractor’s Work are found to be incomplete during applications software testing, then the Contractor shall complete the Work and the 7 days applications software testing period shall be restarted.

5. Owner will be responsible for required changes to the software. However, the Contractor shall be available for assistance related to Contractor supplied equipment.

H. Functional Test: Up to an 8-hour test or tests in the presence of the Engineer and Owner to demonstrate that the installed equipment or system meets manufacturer's installation and adjustment requirements and other requirements specified including, but not limited to, noise, vibration, alignment, speed, proper electrical and mechanical connections, operating temperature, thrust restraint, proper rotation, and initial servicing. Functional tests are typically performed on individual components of a system using clean water or plant effluent.

I. Performance Acceptance Test (PAT): Startup of the entire facility or any unit process thereof shall be considered complete when, in the opinion of the Engineer, the facility or designated unit process has operated in the manner intended for 10 continuous days without significant interruption. A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.

J. Unit Process:

1. The wastewater treatment process, or a portion thereof, that performs a specific function. A unit process may consist of two or more subsystems as well as several types of equipment. The unit process and subsystems on this Project are:
   a. Digester Complex 1 (DC1).
   b. Digester Complex 2 (DC2).
   c. New digester (Digester 3 within DC2).
   d. Digester gas.
   e. Brown Grease Receiving facility feed pumps.
   f. Hot water boilers.
   g. HVAC.

K. Significant Interruption:

1. May include any of the following events:
   a. Failure of Contractor to maintain qualified onsite startup personnel as scheduled.
   b. Failure to meet specified performance for more than 4 consecutive hours.
   c. Failure of any critical equipment unit, system, or subsystem that is not satisfactorily corrected within 4 hours after failure.

d. Failure of noncritical unit, system, or subsystem that is not satisfactorily corrected within 8 hours after failure.
e. As may be determined by Engineer.

L. A day is defined as 24 continuous hours unless noted otherwise.

M. ORT's shall be performed Monday through Thursday.

1.04 SUBMITTALS

A. Submit the Facility Startup Plan in the Startup binder format as described in this section, Supplement Startup Binder.

B. Facility Startup Plan and schedule for Project describing all procedures and showing all activities described or referenced herein. Submit at least 60 days prior to startup of ORT-1. Startup plan shall include:

1. Detailed schedule shall include specific startup related activities on a daily basis. Provide updated schedule weekly or when changes to schedule occur.
2. Summary of shutdown requirements for existing systems which are necessary to complete start-up of new equipment and systems.
3. Name and resume of Startup Coordinator.
4. Provide detailed sub-network of Progress Schedule with the following activities identified:
   a. Manufacturer's services.
   b. Training.
   c. ORT Testing.
   d. Functional testing.
   e. Performance testing.
5. Factory instrument calibration reports.
6. Factory testing reports on all equipment.
7. Field instrument calibration forms.
8. Certification of Proper Installation.
9. Loop and control circuit drawings.
10. Over All Startup Check List (Supplement Over All Startup Check List):
    a. Contractor shall populate and maintain the Tabs in real-time in the Procore Documents section in Start-Up folder. Always work off the same file.
       1) Equipment Check List (populate all columes under "Contractor").
       2) O&M's.
       3) Training List.
       4) Startup Timeline.

11. Electrical Acceptance Sheets: Megger reports.
12. Submit Functional Testing (8-hour test) in writing that all necessary hydraulic structures, piping systems, valves, pump, and HVAC systems have been successfully tested; that all necessary equipment systems and subsystems have been checked for proper installation, started, and successfully tested to indicate that they are all operational; that the systems and subsystems are capable of performing their intended functions; and that the facilities are ready for Functional Testing.

C. Contractor is responsible to maintain the markup startup binder.

D. Within 30 days of the substantial completion submit the red marks startup binder.

1.05 CONTRACTOR FACILITY STARTUP RESPONSIBILITIES

A. General:

1. Provide Startup Coordinator:
    a. Designate and provide one person to be responsible for coordinating and expediting Contractor's testing and startup duties. This person shall be the primary contact for all start-up related activities and communications. The Startup Coordinator shall:
        1) Have experience starting up three facilities similar in size and complexity.
        2) Shall be onsite during all testing and startup meetings and shall be available at all times during the startup period.
        3) Track the testing of each piece of equipment on a shared Microsoft excel spread sheet with the Owner.
            a) See Supplement Over All Startup Check List.
2. It is the Contractor's responsibility to coordinate all work of vendors and subcontractors including, but not limited to, equipment suppliers and representatives, Process Instrumentation and Control System subcontractor, and electrical subcontractor.
    a. Use the Start Up Timeline Tab on a shared Microsoft Excel spreadsheet with owner.
        1) See Supplement Over All Startup Check List.
3. The Contractor shall ensure that all required work, testing, and documentation is completed and submitted in a timely manner to allow for an integrated and organized approach to the startup effort.
4. Prepare testing and startup plan and schedule and attend pretest meetings related to test schedule, and other required Engineer and Owner involvement.
5. Perform all Work for functional and performance test specified.

6. Demonstrate proper function of each component and feature of all equipment, systems, and control devices.
7. Complete all Work associated with the unit and related processes before testing, including related manufacturer's representative services (including training of the Owner's operations and maintenance staff).
8. Provide all related operations and maintenance manuals, and spare parts and special tools as specified before testing any unit or system.
9. Utilize the Supplement Equipment Supplier's Certificate of Proper Installation Form, supplemented as necessary, to document all functional and performance procedures, results, problems, and conclusions.
10. Provide all temporary water pumping, piping, valves, gauges, and other items as required for testing, unless otherwise indicated.
11. Supply and coordinate specified manufacturer's startup services.
12. Make adjustments, repairs, and corrections necessary to complete startup.
13. Prepare all the complete loop drawings for ORT 1 use. Save in Procore, Documents, Startup Folder as "Final Approved Loop Drawings".
14. Populate all the files in in Procore under documents, 560-Startup.

1.06 EQUIPMENT SUPPLIER'S CERTIFICATE OF PROPER INSTALLATION

A. Furnish a copy of Equipment Supplier's Certificate of Proper Installation (See Supplement Equipment Supplier's Certificate of Proper Installation) prepared and signed by manufacturer's authorized representative, certifying equipment along with written report:

1. Has been properly installed, adjusted, aligned, and lubricated.
2. Is free of any stresses imposed by connecting piping or anchor bolts.
3. Is suitable for satisfactory full-time operation under full load conditions.
4. Operates within the allowable limits for vibration.
5. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.

B. See Section 01640, Manufacturers' Services and Training, for additional requirements.

1.07 OWNER/ENGINEER FACILITY STARTUP RESPONSIBILITIES

A. General:

1. Review Contractor's startup test plan and schedule.
2. Review ORT-1 loop and Shop Drawings.
3. Witness testing or review testing documentation.

4. Coordinate other plant operations, if necessary, to facilitate Contractor's tests.
5. Provide non-potable water, wastewater, power, chemicals, and other items as required for testing, unless otherwise indicated.
6. Lab testing coordination if required.

B. Performance Acceptance Test Period:

1. Operate process units and devices, with support of Contractor.
2. Provide sampling labor and provide laboratory analyses for routine process control.
3. Designate and provide one person to be responsible for coordinating and expediting Owner and Engineer's testing and startup duties including interface with plant operations and control system software.
4. Make available special tools and operation and maintenance information for Owner-furnished equipment.

C. Applications Software Provided by Owner:

1. Owner shall be responsible to provide all necessary Plant PLC and SCADA programming.
2. Adjustments and/or corrections of all applications software provided by the Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SEQUENCE OF FACILITY STARTUP ACTIVITIES

A. Owner to schedule planning meetings for Contractor to lead and arrange for attendance by key subs and major equipment manufacturer representatives.

B. Contractor shall make site ready for Owner and engineer to be onsite safely. Owner will make the determination if we can proceed to ORT.

1. All lighting complete.
2. Completion of the equipment check list tab, (Manufacture, Model #, Serial#) to Owner 4 weeks prior to ORT 1.
3. All HVAC ready to be ran as designed: Including Odor Control.

4. Site Work Mostly Completed:
    a. Full permanent access to all equipment.
    b. Sidewalks and curbs completed.
    c. Final sub-grade completed.
    d. All railings shall be fully completed.
    e. Tripping hazards removed, example: temporary power cords and spider boxes.

C. Startup activities shall be completed in the order below. The following steps are not all inclusive and note the major steps:

1. As a guide:
    a. Startup plan is reviewed and ready for implementation.
    b. Factory Acceptance testing.
    c. Electrical Inspections and Testing.
    d. Instrument Calibrations.
    e. Manufacturer's Equipment Acceptance.
    f. Pre-ORT-1.
    g. ORT-1.
    h. Pre-ORT-2.
    i. ORT-2.
    j. Functional Testing.
    k. Performance Acceptance Test.

D. Complete all associated structural, mechanical, instrumentation, and electrical testing.

3.02 TESTING PREPARATION

A. General:

1. Schedule and attend pretest meetings related to test schedule, plan of test, materials, chemicals, and liquids required, facilities' operations interface, Engineer and Owner involvement.
2. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required to conduct testing.

B. Mechanical Systems: As specified in the individual equipment specification sections and the Drawings.

C. Electrical Systems: As specified in Section 16050, Common Work Results for Electrical, and Section 16950, Field Electrical Acceptance Tests.

D. Instrumentation Systems: As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

E. Ready-to-test determination will be made by Engineer based on the following:

1. Notification by Contractor of equipment and system readiness for testing.
2. Adequate completion of Work adjacent to, or interfacing with, equipment to be tested.
3. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment, and satisfactory fulfillment of other specified manufacturers' responsibilities.
4. Upon completion of Pre-ORT-1 listed above in Article Definitions, Paragraph Prerequisite to ORT-1.

F. Cleaning and Checking:

1. Inspect and clean equipment, devices, connected piping, and structures so they are free of foreign material.
2. Lubricate equipment in accordance with manufacturer's instructions.
3. Turn rotating equipment by hand and check motor-driven equipment for correct rotation.
4. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
5. Adjust clearances and torques.
6. Complete piping system pressure testing and cleaning.

3.03 FUNCTIONAL TESTING

A. After successful completion of ORT-1 and ORT-2 begin testing at a time mutually agreed upon by the Owner, Engineer, and Contractor.

B. Engineer will be present during test. Notify in writing Owner, Engineer, and manufacturer's representative(s) at least 10 days prior to scheduled date of functional tests.

C. Conduct continuous 8-hour test under full load conditions. Replace parts which operate improperly.

D. Conduct functional tests as specified for each equipment item or system. Demonstrate correct function of all operational features and control functions.

E. If, in Engineer's opinion, functional test results do not meet requirements specified, the systems will be considered as nonconforming.

3.04 PERFORMANCE ACCEPTANCE TEST (PAT)

A. After successful completion of Functional Testing of the entire facility or any unit process thereof shall be considered complete when, in the opinion of the Engineer, the facility or designated unit process has operated in the manner intended for 10 continuous days. A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.

1. The startup of unit processes shall include the maximum number of interconnected or dependent unit processes in one startup period as approved by the Engineer.
2. The startup period requirement of specified continuous days should as a minimum include the maximum hours of operation per day of process equipment as required to treat current wastewater quantities and process residuals.
3. The startup testing program shall be designed to not interfere with the plant's ability to continuously comply with NPDES Permit requirements.

B. Contractor's superintendent and startup coordinator shall be onsite or available during the entire 10-day test period.

C. General:

1. Contractor to fill out the forms and be accepted by Engineer.
2. Begin testing at time mutually agreed upon by the Engineer, Owner, manufacturers' representative(s), and Contractor, as appropriate.
   a. Engineer will be present during test.
   b. Contractor shall not start or restart a performance test on a Friday, Saturday, Sunday, or the day before an Owner observed holiday. Contractor's superintendent shall be onsite for a minimum of 8 hours after the start or restart of a performance test.
3. Follow approved testing plan and detailed procedures specified.
4. Unless otherwise indicated, furnish all labor, materials, and supplies for conducting the test and taking all samples and performance measurements.
5. Prepare performance test report summarizing test method. Include test logs, pertinent calculations, and certification of performance.

3.05 PARTIAL UTILIZATION

A. After successful testing of a particular equipment type or system, Owner may elect to startup a portion of the equipment or system for continuous operation in accordance with Paragraph 14.10 of the General Conditions. Such operation will not interfere with testing of other equipment and systems that may still be

underway, and shall not preclude the need to startup that portion operated in combination with the rest of the facility when testing is completed.

3.06 CONTINUOUS OPERATIONS

A. Owner will accept equipment and systems as substantially complete and ready for continuous operation only after successful facility startup is completed and documented, and reports submitted, and manufacturers' services completed for training of Owner's personnel excluding post startup training.

3.07 CLEANING

A. After the acceptance tests have been completed:

1. Visually inspect for evidence of discoloration, abnormal dust accumulation, and metal shards, dispose of all testing expendables, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
2. Clean, sweep and remove all garbage from all Work Site locations.

3.08 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Equipment Supplier's Certificate of Proper Installation.
2. Field Instrumentation Calibration Sheet.
3. Startup Binder (Example Table of Contents).
4. Over All Startup Check List.
5. ORT-2 Form.

END OF SECTION

EQUIPMENT SUPPLIER'S CERTIFICATE OF PROPER INSTALLATION

OWNER

PROJECT

CONTRACT NO.

EQUIPMENT SPECIFICATION NO.

EQUIPMENT DESCRIPTION

_____, Authorized representative of
(Print Name)

_____
(Print Manufacturer's Name)

hereby CERTIFY that
(print equipment name and model with serial no.)

_____

_____

installed for the subject project has (have) been installed in a satisfactory manner, has (have) been tested and adjusted, and is (are) ready for final acceptance testing and operation on :

Date:

Time:

CERTIFIED BY: _____
(Signature of Manufacturer's Representative)

Date:

FIELD INSTRUMENTATION CALIBRATION SHEET

Project Name:	Owner Project No. (if applicable):
Project Owner: ABC Company	Regulatory Agency Project No (if applicable)
Project No.: 10050-211-133	Date: 04/20/03
Control Loop No: DM750PIT3400	
Instrument Tag No. 750PIT3400	Transmitter/gauge span:
Manufacturer: ACE, Inc.	Switch set- point:
Model No.: 1275-X	Switch dead band
Serial No: 3049569TSH	Switch range :

TRANSMITTERS AND INDICATORS

	Increasing Input			Decreasing Input		
% of Span	Input	Output	Error (% of span)	Input	Output	Error
0%	0.00 psi	4.02 mA	0.13	0.00 psi	4.00 mA	0.00
25%	50.00 psi	8.00 mA	0.00	50.00 psi	8.01 mA	0.06
50%	100.00 psi	12.01 mA	0.06	100.00 psi	12.00 mA	0.00
75%	150.00 psi	16.00 mA	0.00	150.00 psi	16.01 mA	0.06
100%	200.00 psi	20.00 mA	0.00	200.00 psi	19.99 mA	0.06
Other (if applicable)						
Other (if applicable)						

SWITCHES

Actuation point	Increasing Input			Decreasing Input		
	Input	Output	Error	Input	Output	Error (% of span)
High (increasing input)						
Low (increasing input)						

Maximum Allowable Error (per Contract Docs)_____

Remarks/Comments_____

CALIBRATION EQUIPMENT UTILIZED

Device Type	MFR/Model No.	Accuracy	Nist Traceability Calibration Due Date	Calibration Reference Number
Pressure calibrator	Hathaway/Beta XL 5946P	0.025% Full Scale		
Pressure module	Hathaway/Beta XL 5948P-6:0 – 150 psi	0.025% Full Scale		

Certified by:_____ Date Certified:_____

CLEAN WATER SERVICES
PROJECT NAME: DURHAM WRRF PHASE 6B DIGESTER
PROJECT NO.: 7203

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B. Schedule of manufacturers' startup, equipment certifications and verification of proper installation.

C. Schedule for submitting final owner’s manuals.

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1.06 EQUIPMENT STARTUP, TESTING, CALIBRATION, AND FUNCTIONAL TESTING

A. Gravity pipeline testing.

B. Pressure pipeline testing and disinfection.

C. Water tightness testing.

D. Process Area (Place holder for each process area in Project, repeat all items under heading 1.06 D).

1. Control strategy descriptions/P&ID Drawings/Loop Drawings/Interconnect diagrams for standalone equipment.
2. Certificate calibration sheets.
3. Final approved Loop Drawings for ORT 1.
4. Equipment Supplier's Certificate of Proper Installation and technical references.
    a. List all the specification sections used.

E. Digester 3 (reference):

1. Control strategy descriptions.
    a. Digesters 1, 2 and 3 Mixers.
2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets,
4. ORT 1 Loop Drawings.
5. Equipment Supplier's Certificate of Proper Installation: Prefilled out and ready for field completion.
    a. Section 11383, Digester Gas Safety Equipment.
    b. Section 11385, Digester Mixer.
    c. Section 17208, Level Measurement: Radar.
    d. Section 17305, Flow Measurement: Thermal Mass.
    e. Section 17406, Pressure/Vacuum: Differential.

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1. Control strategy descriptions.
    a. Sludge Grinders.
    b. Sludge Recirculation Pumps.
    c. DC 2 Digester Temperature Control.
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    h. DC 2 Air Handling Unit.
2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets.
4. ORT 1 Loop Drawings.
5. Equipment Supplier's Certificate of Proper Installation: Prefilled out and ready for field completion.
    a. Section 11203, In-line Sludge Grinders.
    b. Section 11311, Non-clog Dry-pit Centrifugal Pumps.
    c. Section 11382, Sludge Heat Exchanger.

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1. Control strategy descriptions.
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2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets.
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5. Equipment Supplier’s Certificate of Proper Installation: Prefilled out and ready for field completion.
   a. Section 11315, Progressive Cavity Pumps.
   b. Section 15120, Hydronic Specialties.
   c. Section 15202, Process Valves and Operators.
   d. Section 16262, Variable Frequency Drives.
   e. Section 17403, Pressure/Vacuum: Switches.
   f. Section 17604, Temperature Measurement: RTD.

H. Digester Complex 1 (reference):

1. Control strategy descriptions.
2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets.
4. ORT 1 Loop Drawings.
5. Equipment Supplier’s Certificate of Proper Installation: Pre-filled out and ready for field completion.
   a. Section 17604, Temperature Measurement: RTD.

I. Digester Complex 1 Waste Gas Burner (reference):

1. Control strategy descriptions.
   a. DC 1 and DC 2 Waste Gas Burner Flow Control.
2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets.
4. ORT 1 Loop Drawings.
5. Equipment Supplier’s Certificate of Proper Installation: Prefilled out and ready for field completion.
   a. Section 11383, Digester Gas Safety Equipment.
   b. Section 15202, Process Valves and Operators.
   c. Section 17305, Flow Measurement: Thermal Mass.

J. Solids Building (reference):

1. Control strategy descriptions.
   a. Digester Feed Pumps.
2. P&ID Drawings/Interconnect diagrams for standalone equipment.
3. Certificate calibration sheets.
4. ORT 1 Loop Drawings.
5. Equipment Supplier’s Certificate of Proper Installation: Prefilled out and ready for field completion.
   a. Section 15202, Process Valves and Operators.
   b. Section 17604, Temperature Measurement: RTD.

1.07 FACILITY STARTUP AND COMMISSIONING PROCEDURES

A. List all the process areas in the Project:

1. Digester 3.
2. Digester Complex 2.
3. Brown Grease Receiving Facility.
4. Digester Complex 1.
5. Digester Complex 1 Waste Gas Burner.
6. Solids Building.

1.08 APPENDIX

A. IO Addressing List.

B. Local Control Stations:

1. List.

SPECIFICATION SECTION 01756 - SUP 4

Project Name	DM Phase 6B Digester		**Engineer**	Jacobs Engineering Group	**General Contractor**		**Electrical Contractor**	
CIP Number	7203		**Facility**	Durham	**PM / CM**		**Integrator Contractor**	

Engineering							Contractor Check List Pre ORT 1												Owner Check List Pre ORT 1			Owner Check List After Startup			
							Check	Fill In					UR Link from Procore Startup folders or N/A						Drop Down List						
New, Deleted, Re-Purposed	**Equipment Tag Number**	**Equipment Description**	**Location on Site**	**Power Feed**	**I/O Address**	**Warranty Beyond 1 Year**	**Name Plate Photo**	**Manufacturer**	**Model #**	**Serial #**	**Est. Cost**	**Est. Life**	**Certificate of Proper Installation**	**Manufacturer's Services/Field Report**	**Factory Calibration or FAT Report**	**Approved Shop Drawings**	**Wire/Motor Test Report**	**Field Calibration**	**Check O&M Tab**	**Final Loop Drawings for ORT 1**	**ORT 2**	**PAT**	**Check Training & O&M Tab**	**Substantial Completion/ Warranty Date**
Re-Purposed	740BNR6904	DC 1 WASTE GAS BURNER	SOUTH OF GRAVITY THICKENER 4																					
New	740FE6904	DC 1 WASTE GAS BURNER FLOW ELEMENT	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
New	740FIT6904	DC 1 WASTE GAS BURNER FLOW TRANSMITTER	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
Re-Purposed	740LCP6904	DC 1 WASTE GAS BURNER LOCAL CONTROL PANEL	SOUTH SIDE OF GRAVITY THICKENER 4																					
New	740CS6904	DC 1 WASTE GAS BURNER SPARK GENERATOR PANEL	SOUTH SIDE OF GRAVITY THICKENER 4																					
New	740UPS6904	DC 1 WASTE GAS BURNER UPS	DIGESTER COMPLEX 1, ELECTRICAL ROOM																					
New	740FA6904	DC 1 WASTE GAS BURNER FLAME ARRESTER	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
New	740FCV6904	DC 1 WASTE GAS BURNER FLOW CONTROL BYPASS VALVE	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
New	740FCV6904-ACT	DC 1 WASTE GAS BURNER FLOW CONTROL BYPASS ACTUATOR	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
New	740PRV6904	DC 1 WASTE GAS BURNER PRESSURE REGULATING VALVE	DIGESTER COMPLEX 1 WASTE GAS BURNER																					
New	715P6406	FOG WASTE FEED PUMP 3	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715M6406	FOG WASTE FEED PUMP 3 MOTOR	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715VFD6406	FOG WASTE FEED PUMP 3 VFD	BROWN GREASE RECEIVING FACILITY, ELECTRICAL ROOM																					
New	715P6406-LCS	FOG WASTE FEED PUMP 3 LOCAL CONTROL STATION	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715TSH6406	FOG WASTE FEED PUMP 3 TEMPERATURE SWITCH HIGH	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715PE6406	FOG WASTE FEED PUMP 3 DISCHARGE PRESSURE ELEMENT	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715PI6406	FOG WASTE FEED PUMP 3 DISCHARGE PRESSURE INDICATOR	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715PSH6406	FOG WASTE FEED PUMP 3 DISCHARGE HIGH PRESSURE SWITCH	BROWN GREASE RECEIVING FACILITY, PUMP ROOM																					
New	715P6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION PUMP	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715M6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION PUMP MOTOR	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715MS6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION PUMP LOCAL CONTROL STATION	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715BV6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION BALANCING VALVE	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	725P6706	DC 2 SLUDGE RECIRCULATION PUMP 6	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6706	DC 2 SLUDGE RECIRCULATION PUMP 6 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725MS6706	DC 2 SLUDGE RECIRCULATION PUMP 6 MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6706-LCS	DC 2 SLUDGE RECIRCULATION PUMP 6 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6706A	DC 2 SLUDGE RECIRCULATION PUMP 6 INLET PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725PI6706A	DC 2 SLUDGE RECIRCULATION PUMP 6 INLET PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6706B	DC 2 SLUDGE RECIRCULATION PUMP 6 DISCHARGE PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725PI6706B	DC 2 SLUDGE RECIRCULATION PUMP 6 DISCHARGE PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725GDR6706	DC 2 SLUDGE RECIRCULATION GRINDER 6	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6706	DC 2 SLUDGE RECIRCULATION GRINDER 6 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725VFD6706	DC 2 SLUDGE RECIRCULATION GRINDER 6 VFD	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725GDR6706-LCS	DC 2 SLUDGE RECIRCULATION GRINDER 6 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6616	DC 2 BUILDING HOT WATER FLOW CONTROL VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6616-ACT	DC 2 BUILDING HOT WATER FLOW ACTUATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725BV6616	DC 2 BUILDING HOT WATER BALANCING VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6618	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER FLOW CONTROL VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6618-ACT	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER ACTUATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725BV6618A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER BALANCING VALVE 1	DIGESTER COMPLEX 2, BASEMENT																					
New	725BV6618B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER BALANCING VALVE 2	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6611S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER SUPPLY TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6611S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER SUPPLY TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6611R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER RETURN TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6611R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER RETURN TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725FE6701	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE FLOW ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725FIT6701	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE FLOW TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6701A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6701A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE INLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6701B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE OUTLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6701B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE OUTLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6619	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER FLOW CONTROL VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6619-ACT	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER FLOW CONTROL VALVE ACTUATOR																						
New	725BV6619A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER BALANCING VALVE 1	DIGESTER COMPLEX 2, BASEMENT																					
New	725BV6619B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER BALANCING VALVE 2	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6612S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER SUPPLY TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6612S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER SUPPLY TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6612R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER RETURN TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6612R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER RETURN TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725FE6702	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE FLOW ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725FIT6702	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE FLOW TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6702A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6702A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6702B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6702B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725HX6703	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3	DIGESTER COMPLEX 2, BASEMENT																					
New	725P6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER PUMP	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER PUMP MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725MS6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER PUMP MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6613-LCS	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER PUMP LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER FLOW CONTROL VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV6613-ACT	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER FLOW CONTROL VALVE ACTUATOR																						
New	725BV6613A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER BALANCING VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725BV6613B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER BALANCING VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725P6703	DC 2 SLUDGE RECIRCULATION PUMP 3	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6703	DC 2 SLUDGE RECIRCULATION PUMP 3 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725MS6703	DC 2 SLUDGE RECIRCULATION PUMP 3 MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6703-LCS	DC 2 SLUDGE RECIRCULATION PUMP 3 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6703A	DC 2 SLUDGE RECIRCULATION PUMP 3 INLET PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725PI6703A	DC 2 SLUDGE RECIRCULATION PUMP 3 INLET PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6703B	DC 2 SLUDGE RECIRCULATION PUMP 3 DISCHARGE PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725PI6703B	DC 2 SLUDGE RECIRCULATION PUMP 3 DISCHARGE PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725GDR6703	DC 2 SLUDGE RECIRCULATION GRINDER 3	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6703	DC 2 SLUDGE RECIRCULATION GRINDER 3 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725VFD6703	DC 2 SLUDGE RECIRCULATION GRINDER 3 VFD	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725GDR6703-LCS	DC 2 SLUDGE RECIRCULATION GRINDER 3 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6613S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER SUPPLY TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6613S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER SUPPLY TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6613R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER RETURN TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6613R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER RETURN TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725FE6703	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE FLOW ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725FIT6703	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE FLOW TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6703A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6703A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725TE6703B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725TIT6703B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725P6704	DC 2 SLUDGE RECIRCULATION PUMP 4	DIGESTER COMPLEX 2, BASEMENT																					
New	725M6704	DC 2 SLUDGE RECIRCULATION PUMP 4 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725MS6704	DC 2 SLUDGE RECIRCULATION PUMP 4 MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6704-LCS	DC 2 SLUDGE RECIRCULATION PUMP 4 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6704A	DC 2 SLUDGE RECIRCULATION PUMP 4 INLET PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725PI6704A	DC 2 SLUDGE RECIRCULATION PUMP 4 INLET PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725PE6704B	DC 2 SLUDGE RECIRCULATION PUMP 4 DISCHARGE PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					

New, Deleted, Re-Purposed	Equipment Tag Number	Equipment Description	Location on Site	Power Feed	I/O Address	Warranty Beyond 1 Year	Name Plate Photo	Manufacturer	Model #	Serial #	Est. Cost	Est. Life	Certificate of Proper Installation	Manufacturer's Services/Field Report	Factory Calibration or FAT Report	Approved Shop Drawings	Wire/Motor Test Report	Field Calibration	Check O&M Tab	Final Loop Drawings for ORT 1	ORT 2	PAT	Check Training & O&M Tab	Substantial Completion/ Warranty Date
New	725PI6704B	DC 2 SLUDGE RECIRCULATION PUMP 4 DISCHARGE PRESSURE INDICATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725GDR6704	DC 2 SLUDGE RECIRCULATION GRINDER 4	DIGESTER COMPLEX 2, BASEMENT																					
New	725GDR6704-M	DC 2 SLUDGE RECIRCULATION GRINDER 4 MOTOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725VFD6704	DC 2 SLUDGE RECIRCULATION GRINDER 4 VFD	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725GDR6704-LCS	DC 2 SLUDGE RECIRCULATION GRINDER 4 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV3801	DC 2 DIGESTER 3 FLOW CONTROL VALVE	DIGESTER COMPLEX 2, BASEMENT																					
New	725FCV3801-ACT	DC 2 DIGESTER 3 FLOW CONTROL VALVE ACTUATOR	DIGESTER COMPLEX 2, BASEMENT																					
New	725FE6401	DC 2 DIGESTER 3 FOG WASTE FEED FLOW ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
New	725FIT6401	DC 2 DIGESTER 3 FOG WASTE FEED FLOW TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
New	725P6601	DC 2 PRIMARY HEAT LOOP PUMP 1	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725M6601	DC 2 PRIMARY HEAT LOOP PUMP 1 MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	72VFDP6601	DC 2 PRIMARY HEAT LOOP PUMP 1 VFD	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6601-LCS	DC 2 PRIMARY HEAT LOOP PUMP 1 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725P6602	DC 2 PRIMARY HEAT LOOP PUMP 2	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725M6602	DC 2 PRIMARY HEAT LOOP PUMP 2 MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725VFDP6602	DC 2 PRIMARY HEAT LOOP PUMP 2 VFD	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6602-LCS	DC 2 PRIMARY HEAT LOOP PUMP 2 LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725PIT6601A	DC 2 PRIMARY HEAT LOOP PUMP INLET PRESSURE TRANSMITTER	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725PIT6601B	DC 2 PRIMARY HEAT LOOP PUMP DISCHARGE PRESSURE TRANMITTER	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725BLR6623	DC 2 BOILER 3	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725P6623	DC 2 BOILER 3 HOT WATER LOOP PUMP	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725M6623	DC 2 BOILER 3 HOT WATER LOOP PUMP MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725MS6623	DC 2 BOILER 3 HOT WATER LOOP PUMP MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6623-LCS	DC 2 BOILER 3 HOT WATER LOOP PUMP LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725TE6623	DC 2 BOILER 3 FEED INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725TI6623	DC 2 BOILER 3 FEED INLET TEMPERATURE INDICATOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725PRV7123	DC 2 BOILER 3 NATURAL GAS PRESSURE REDUCING VALVE	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725BV6623	DC 2 BOILER 3 HOT WATER RETURN BALANCING VALVE	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725BLR6624	DC 2 BOILER 4	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725P6624	DC 2 BOILER 4 HOT WATER LOOP PUMP	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725M6624	DC 2 BOILER 4 HOT WATER LOOP PUMP MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725MS6624	DC 2 BOILER 4 HOT WATER LOOP PUMP MOTOR STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725P6624-LCS	DC 2 BOILER 4 HOT WATER LOOP PUMP LOCAL CONTROL STATION	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725TE6624	DC 2 BOILER 4 FEED INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725TI6624	DC 2 BOILER 4 FEED INLET TEMPERATURE INDICATOR	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725PRV7124	DC 2 BOILER 4 NATURAL GAS PRESSURE REDUCING VALVE	DIGESTER COMPLEX 2, BOILER ROOM																					
New	725BV6624	DC 2 BOILER 4 HOT WATER RETURN BALANCING VALVE	DIGESTER COMPLEX 2, BOILER ROOM																					
New	720TE6601A	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 1, BASEMENT																					
New	720TIT6601A	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 1, BASEMENT																					
New	720TE6601B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 1, BASEMENT																					
New	720TIT6601B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 1, BASEMENT																					
New	720TE6602A	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 1, BASEMENT																					
New	720TIT6602A	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 1, BASEMENT																					
New	720TE6602B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE ELEMENT	DIGESTER COMPLEX 1, BASEMENT																					
New	720TIT6602B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE TRANSMITTER	DIGESTER COMPLEX 1, BASEMENT																					
New	725T6503	DC 2 DIGESTER 3	DIGESTER COMPLEX 2, NORTHEAST DIGESTER																					
New	725MX6503	DC 2 DIGESTER 3 MIXER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725M6503	DC 2 DIGESTER 3 MIXER MOTOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725MS6503	DC 2 DIGESTER 3 MIXER MOTOR STARTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725MX6503-LCS	DC 2 DIGESTER 3 MIXER LOCAL CONTROL STATION	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725P9201	DC 2 DIGESTER 3 MIXER LUBE PUMP	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725M9201	DC 2 DIGESTER 3 MIXER LUBE PUMP MOTOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725MS9201	DC 2 DIGESTER 3 MIXER LUBE PUMP MOTOR STARTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725P9201-LCS	DIGESTER 3 MIXER LUBE PUMP LOCAL CONTROL STATION	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725FSL6503	DIGESTER 3 MIXER LUBE PUMP FLOW SWITCH	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725HTR9201	DIGESTER 3 MIXER LUBE HEATER																						
New	725FI6911	DC 2 DIGESTER 3 NPW SCUM BOX FLOW INDICATOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725FI6912	DC 2 DIGESTER 3 NPW FOAM SEPERATOR FLOW INDICATOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725FI6913	DC 2 DIGESTER 3 NPW MIXER SEAL WATER FLOW INDICATOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725PE6903	DC 2 DIGESTER 3 DIGESTER GAS PRESSURE ELEMENT	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725PIT6903	DC 2 DIGESTER 3 DIGESTER GAS PRESSURE TRANSMITTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725LIT6503	DC 2 DIGESTER 3 SLUDGE LEVEL RADAR TRANSMITTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725FE6903	DC 2 DIGESTER 3 DIGESTER GAS FLOW ELEMENT	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725FIT6903	DC 2 DIGESTER 3 DIGESTER GAS FLOW TRANSMITTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725LE6904A	DC 2 DIGESTER 3 SLUDGE LEVEL DIFFERENTIAL UPPER ELEMENT	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725LE6904B	DC 2 DIGESTER 3 SLUDGE LEVEL DIFFERENTIAL LOWER ELEMENT	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725LIT6904	DC 2 DIGESTER 3 SLUDGE LEVEL DIFFERENTIAL TRANSMITTER	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725PSV6503A	DC 2 DIGESTER 3 PRESSURE VACUUM RELIEF VALVE A	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725PSV6503B	DC 2 DIGESTER 3 PRESSURE VACUUM RELIEF VALVE B	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725HCC0001	DC 2 DIGESTER 3 HEAT TRACE CONTACTOR	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725SEP6921	DC 2 DIGESTER 3 CONDENSATE AND SEDIMENT TRAP	DIGESTER COMPLEX 2, DIGESTER 3																					
New	725SEP6920	DC 2 DIGESTER 3 FOAM SEPARATOR	DIGESTER COMPLEX 2, DIGESTER 3																					
Re-Purposed	715P6601	SECONDARY HEAT LOOP PUMP 1	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
Re-Purposed	715M6601	SECONDARY HEAT LOOP PUMP 1 MOTOR	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
Re-Purposed	715VFD6601	SECONDARY HEAT LOOP PUMP 1 VFD	BROWN GREASE RECEIVING FACILITY, ELECTRICAL ROOM																					
Re-Purposed	715P6601-LCS	SECONDARY HEAT LOOP PUMP 1 LOCAL CONTROL STATION	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
Re-Purposed	715P6602	SECONDARY HEAT LOOP PUMP 2	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
Re-Purposed	715M6602	SECONDARY HEAT LOOP PUMP 2 MOTOR	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
Re-Purposed	715VFD6602	SECONDARY HEAT LOOP PUMP 2 VFD	BROWN GREASE RECEIVING FACILITY, ELECTRICAL ROOM																					
Re-Purposed	715P6602-LCS	SECONDARY HEAT LOOP PUMP 2 LOCAL CONTROL STATION	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715FCV6611	SECONDARY HEAT LOOP FLOW CONTROL VALVE	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715FCV6611-ACT	SECONDARY HEAT LOOP ACTUATOR	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	715BV6611	SECONDARY HEAT LOOP BALANCING VALVE	BROWN GREASE RECEIVING FACILITY, MECHANICAL ROOM																					
New	710FV3811	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE DC 1	SOLIDS BUILDING, LOWER BASEMENT																					
New	710FV3812	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE SWING	SOLIDS BUILDING, LOWER BASEMENT																					
New	710FV3813	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE DC 2	SOLIDS BUILDING, LOWER BASEMENT																					
New	725LCP9601	PLC-26 (OWNER SUPPLIED)	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725LE6801	DC 2 DIGESTED SLUDGE SUMP LEVEL ELEMENT	DIGESTER COMPLEX 2, DIGESTED SLUDGE SUMP																					
New	725LIT6801	DC 2 DIGESTED SLUDGE SUMP LEVEL TRANSMITTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
New	725AHU5001	DC 2 ELECTRICAL ROOM AIR HANDLING UNIT	DIGESTER COMPLEX 2, PENTHOUSE																					
New	725ACU5001	DC 2 ELECTRICAL ROOM CONDENSING UNIT	DIGESTER COMPLEX 2, PENTHOUSE																					
New	725TIC5001	DC 2 ELECTRICAL ROOM THERMOSTAT	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
Deleted	FM10004	DC1 WASTE GAS BURNER FLOW ELEMENT	DIGESTER COMPLEX 1 GAS ROOM																					
Deleted	FIT10004	DC1 WASTE GAS BURNER FLOW INDICATING TRANSMITTER	DIGESTER COMPLEX 1 GAS ROOM																					
		DIGESTER GAS BLOWERS	DIGESTER COMPLEX 1 GAS ROOM																					
Deleted	20ZS10201	DC2 SLUDGE RECIRC PLUMP CHECK VALVE LIMIT SWITCH	DIGESTER COMPLEX 2, BASEMENT																					
Deleted	20ZS10202	DC2 SLUDGE RECIRC PLUMP CHECK VALVE LIMIT SWITCH	DIGESTER COMPLEX 2, BASEMENT																					
Deleted	20PE10401	DIGESTER 1 PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
Deleted	20LIT10401	DIGESTER 1 PRESSURE TRANSDUCER LEVEL INDICATING TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					
Deleted	20PE10402	DIGESTER 2 PRESSURE ELEMENT	DIGESTER COMPLEX 2, BASEMENT																					
Deleted	20LIT10402	DIGESTER 2 PRESSURE TRANSDUCER LEVEL INDICATING TRANSMITTER	DIGESTER COMPLEX 2, BASEMENT																					

New, Deleted, Re-Purposed	Equipment Tag Number	Equipment Description	Location on Site	Power Feed	I/O Address	Warranty Beyond 1 Year	Name Plate Photo	Manufacturer	Model #	Serial #	Est. Cost	Est. Life	Certificate of Proper Installation	Manufacturer's Services/Field Report	Factory Calibration or FAT Report	Approved Shop Drawings	Wire/Motor Test Report	Field Calibration	Check O&M Tab	Final Loop Drawings for ORT 1	ORT 2	PAT	Check Training & O&M Tab	Substantial Completion/ Warranty Date
Deleted	20M20101	PRIMARY HEAT LOOP PUMP 1 MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
Deleted	20M20102	PRIMARY HEAT LOOP PUMP 2 MOTOR	DIGESTER COMPLEX 2, BOILER ROOM																					
Deleted	20MS20101	PRIMARY HEAT LOOP PUMP 1 STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
Deleted	20MS20102	PRIMARY HEAT LOOP PUMP 2 STARTER	DIGESTER COMPLEX 2, ELECTRICAL ROOM																					
Deleted	20P20101	PRIMARY HEAT LOOP PUMP 1	DIGESTER COMPLEX 2, BOILER ROOM																					
Deleted	20P20102	PRIMARY HEAT LOOP PUMP 2	DIGESTER COMPLEX 2, BOILER ROOM																					
Deleted	20F99803	DC2 ELECTRICAL ROOM AIR HANDLING UNIT	DIGESTER COMPLEX 2, PENTHOUSE																					
Deleted	20F99801	DC2 ELECTRICAL ROOM CONDENSING UNIT	DIGESTER COMPLEX 2, PENTHOUSE																					
Delete	20LIT10601	DIGESTED SLUDGE SUMP LEVEL TRANSMITTER - REPLACE WITH NEW	DIGESTER COMPLEX 2																					

Spec	Name	First Rev Link	First Rev Date	Final Electronic Link	Final Electronic Date	Final Hard Copy Date	Comments	Supplier
11203	In-line Sludge Grinders							
11311	Non-clog Dry-pit Centrifugal Pumps							
11315	Progressive Cavity Pumps							
11382	Sludge Heat Exchanger							
11383	Digester Gas Safety Equipment							
11385	Digester Mixer							
15120	Hydronic Specialties							
15202	Process Valves and Operators (Actuators)							
15500	Heating Boilers							
15720	Air Handling Units							
15730	Unitary Air-Conditioning Equipment							
15900	Instrumentation and Control Devices for HVAC							
15901	HVAC Controls, Fiels Components, and Instruments							
15950	Testing, Adjusting, and Balancing for HVAC							
16262	Variable Frequency Drives							
16444	Low Voltage Motor Control Centers							
17208	Level Measurement: Radar							
17305	Flow Measurement: Thermal Mass							
17310	Flow Measurement: Ultrasonic Time of Flight							
17311	Flow Measurement: Ultrasonic Doppler Flowmeters							
17316	Rotameters							
17401	Pressure/Vacuum Measurment: Diaphragm and Annular Seals							
17402	Pressure/Vacuum Measurment: Instrument Valves							
17403	Pressure/Vacuum: Switches							
17405	Pressure/Vacuum: Direct							
17406	Pressure/Vacuum: Differential							
17604	Temperature Measurement: RTD							
17710	Control Systems							
17050	Loop Drawings							

Spec Section	Equipment Type	# of Sessions	Hours	# of Sessions	Hours	# of Sessions	Hours	Outline Submitted	Outline Approved	Training Scheduled	Training Received
		Maintenance		Operator		E&I					
11383	Digester Gas Safety Equipment	1	4	1	2	1	4				
11385	Digester Mixer	1	4	1	1	1	4				
15202	Process Valves and Operators (Actuators)					1	4				
15500	Heating Boilers	1	4	1	1	1	8				
15720	Air Handling Units	1	4	1	1	1	4				
15730	Unitary Air-Conditioning Equipment	1	4	1	1	1	4				
15900	Instrumentation and Control Devices for HVAC	1	4	1	1	1	4				
16262	Variable Frequency Drives					1	8				
17208	Level Measurement: Radar			1	1	1	4				
17305	Flow Measurement: Thermal Mass			1	1	1	4				
17310	Flow Measurement: Ultrasonic Time of Flight					1	4				
17311	Flow Measurement: Ultrasonic Doppler Flowmeters					1	4				

	Training Preference Day and Time
Operations	Wednesdays at 2pm
Maintenance	Tuesday, Wednesday 7am - 2pm
Electrical & Instrumentation	Tuesday, Wednesday 7am - 2pm

Startup Timeline - Example

					Attendance						
		Time	**Date**	**Notes**	**General**	**CWS**	**Intergrator**	**Electrical**	**Manufacturer Rep**	**Programmer**	**Status**
Prior to Week 1											
	Pre ORT										
	Housekeeping										
	Verify all piping is clear of all debris										
	Verify digester is clear of debris										
	Verify all electrical panels and enclosures are clear of all debris										
	Site made safe - guardrails, stairs, cover holes, etc.										
	Gravity Pipeline Testing										
	(list all services)										
	Pressure Pipeline Testing										
	(list all services)										
	Water Tightness Structure Testing										
	Electrical										
	Lighting complete										
	Megger reports										
	CAT 6 test report										
	Instrumentation										
	PLC I/O and Ethernet switches										
	Pressure switch factory calibration reports										
	Flowmeter factory calibration reports										
	Field instrument calibration forms										
	Local Control Stations and Control Panels (VFD)										
	Factory acceptance test and reports										
	Loop Drawings - Construction Set										
	Programming and SCADA screens										
Week X	725 - Digester Complex 2										
	Manufacturer Startup & Checkout on Boiler and Primary Heat Loop Pumps										
	ORT-1										
	ORT-2										
	Boilers										
	Primary Heat Loop Pumps										
	8 Hour Run Test										

					Attendance						
		Time	**Date**	**Notes**	**General**	**CWS**	**Intergrator**	**Electrical**	**Manufacturer Rep**	**Programmer**	**Status**
Week X	715 - FOG Bldg										
	Manufacturer Startup & Checkout on Secondary Heat Loop Pumps										
	ORT-1										
	ORT-2										
	Secondary Heat Loop Pumps										
	8 Hour Run Test										
Week 1	**725 - Digester 3**										
	Manufacturer Startup & Checkout on Mixer										
	ORT-1: Radar Level, Differential Level, Thermal Mass FM, Vertical Mixer										
	ORT-2: Radar Level, Differential Level, Thermal Mass FM, Vertical Mixer										
Week 2	**725 - Digester Complex 2**										
	Manufacturer Startup & Checkout on Pumps/Grinders/Heat Exchanger/Valve Actuators/VFD										
	ORT-1: Ultrasonic FM, Pressure, Temperature										
	ORT-2: Ultrasonic FM, Pressure, Temperature										
	Check Pressure, Flow, and Temperature on Pressure Transmitters, Ultrasonic Meters, Temperature Transmitters										
	Check Operation of Actuated Valves										
	8 Hour Grinder, Pump, and Heat Exchanger Run Test										
Week 3	**720 - Digester 1 Complex**										
	Manufacturer Startup & Checkout										
	Check Flows on Thermal Mass Flowmeters										
	Check Operation on Actuated Valves										
	Confirm Readings on Pressure Transmitters										
Week 4	**750 - Solids Building**										
	Manufacturer Startup & Checkout										
	Check Operation on Actuated Valves										
Week 5	**715 - FOG Bldg**										
	Manufacturer Startup & Checkout										
	Check Operation on Actuated Valves										
	Confirm Readings on Pressure Transmitters										
	8 Hour Pump Run Test										
	All Locations										
Week 6	Transfer sludge to digester 3										
	Performance Testing on All Systems										

Done	Sheet #	Tag #	Title	Field Notes/Action Items	Date
		740FIT6904	DC1 WASTE GAS BURNER FLOW TRANSMITTER		
		740FCV6904	DC1 WASTE GAS BURNER FLOW CONTROL BYPASS VALVE		
		715P6406	FOG WASTE FEED PUMP 3		
		715TSH6406	FOG WASTE FEED PUMP 3 TEMPERATURE SWITCH HIGH		
		715PE6406	FOG WASTE FEED PUMP 3 DISCHARGE PRESSURE ELEMENT		
		715PSH6406	FOG WASTE FEED PUMP 3 DISCHARGE HIGH PRESSURE SWITCH		
		715P6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION PUMP		
		725P6706	DC 2 SLUDGE RECIRCULATION PUMP 6		
		725PE6706A	DC2 SLUDGE RECIRCULATION PUMP 6 INLET PRESSURE ELEMENT		
		725PE6706B	DC2 SLUDGE RECIRCULATION PUMP 6 DISCHARGE PRESSURE ELEMENT		
		725GDR6706	DC 2 SLUDGE RECIRCULATION GRINDER 6		
		725FCV6616	DC 2 BUILDING HOT WATER FLOW CONTROL VALVE		
		725FCV6618	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER FLOW CONTROL VALVE		
		725TIT6611S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER SUPPLY TEMPERATURE TRANSMITTER		
		725TIT6611R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER RETURN TEMPERATURE TRANSMITTER		
		725FIT6701	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE FLOW TRANSMITTER		
		725TIT6701A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE INLET TEMPERATURE TRANSMITTER		
		725TIT6701B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE OUTLET TEMPERATURE TRANSMITTER		
		725FCV6619	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER FLOW CONTROL VALVE		
		725TIT6612S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER SUPPLY TEMPERATURE TRANSMITTER		
		725TIT6612R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER RETURN TEMPERATURE TRANSMITTER		
		725FIT6702	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE FLOW TRANSMITTER		
		725TIT6702A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE TRANSMITTER		
		725TIT6702B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE TRANSMITTER		
		725P6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER HOT WATER PUMP 3		
		725FCV6613	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER FLOW CONTROL VALVE		
		725P6703	DC 2 SLUDGE RECIRCULATION PUMP 3		
		725PE6703A	DC2 SLUDGE RECIRCULATION PUMP 3 INLET PRESSURE ELEMENT		
		725PE6703B	DC2 SLUDGE RECIRCULATION PUMP 3 DISCHARGE PRESSURE ELEMENT		
		725GDR6703	DC 2 SLUDGE RECIRCULATION GRINDER 3		
		725TIT6613S	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER SUPPLY TEMPERATURE TRANSMITTER		
		725TIT6613R	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER RETURN TEMPERATURE TRANSMITTER		
		725FIT6703	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE FLOW TRANSMITTER		
		725TIT6703A	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE TRANSMITTER		
		725TIT6703B	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE TRANSMITTER		
		725P6704	DC 2 SLUDGE RECIRCULATION PUMP 4		
		725PE6704A	DC2 SLUDGE RECIRCULATION PUMP 4 INLET PRESSURE ELEMENT		
		725PE6704B	DC2 SLUDGE RECIRCULATION PUMP 4 DISCHARGE PRESSURE ELEMENT		
		725GDR6704	DC 2 SLUDGE RECIRCULATION GRINDER 4		
		725FV3801	DC 2 DIGESTER 3 FLOW CONTROL VALVE		
		725FIT6401	DC 2 DIGESTER 3 FOG WASTE FEED FLOW TRANSMITTER		
		725P6601	DC 2 PRIMARY HEAT LOOP PUMP 1		
		725P6602	DC 2 PRIMARY HEAT LOOP PUMP 2		
		725PIT6601A	DC 2 PRIMARY HEAT LOOP PUMP INLET PRESSURE TRANSMITTER		
		725PIT6601B	DC 2 PRIMARY HEAT LOOP PUMP DISCHARGE PRESSURE TRANMITTER		
		725BLR6623	DC 2 BOILER 3		
		725P6623	DC 2 BOILER 3 HOT WATER LOOP PUMP		
		725TE6623	DC 2 BOILER 3 FEED INLET TEMPERATURE ELEMENT		
		725BLR6624	DC 2 BOILER 4		
		725P6624	DC 2 BOILER 4 HOT WATER LOOP PUMP		
		725TE6624	DC 2 BOILER 4 FEED INLET TEMPERATURE ELEMENT		

Done	Sheet #	Tag #	Title	Field Notes/Action Items	Date
		720TIT6601B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE TRANSMITTER		
		720TIT6601B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE TRANSMITTER		
		720TIT6602B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE TRANSMITTER		
		720TIT6602B	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE TRANSMITTER		
		725MX6503	DIGESTER 3 MIXER		
		725P9201	DIGESTER 3 MIXER LUBE PUMP		
		725FSL6503	DIGESTER 3 MIXER LUBE PUMP FLOW SWITCH		
		725PIT6903	DC2 DIGESTER 3 DIGESTER GAS PRESSURE TRANSMITTER		
		725LIT6503	DC2 DIGESTER 3 SLUDGE LEVEL RADAR TRANSMITTER		
		725FIT6903	DC2 DIGESTER 3 DIGESTER GAS FLOW TRANSMITTER		
		725LIT6904	DC2 DIGESTER 3 SLUDGE LEVEL DIFFERENTIAL TRANSMITTER		
		715P6501	FOG OFFLOADING SCREEN HOT WATER RECIRCULATION PUMP		
		715P6601	SECONDARY HEAT LOOP PUMP 1		
		715P6602	SECONDARY HEAT LOOP PUMP 2		
		715FCV6611	SECONDARY HEAT LOOP FLOW CONTROL VALVE		
		710FV3811	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE DC1		
		710FV3812	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE SWING		
		710FV3813	DIGESTER FEED PUMP DISCHARGE MANIFOLD CONTROL VALVE DC2		

Example to be used

Equipment Tag Number	Equipment Description	E-Tap/Location	IP Address
725BLR6623-LCS	DC 2 Boiler 3	E-Tap X PLC 26	
725BLR6624-LCS	DC 2 Boiler 4	E-Tap X PLC 26	
725VFD6703	Sludge Recirculation Grinder 3 VFD	E-Tap X PLC 26	
725VFD6704	Sludge Recirculation Grinder 4 VFD	E-Tap X PLC 26	
725VFD6706	Sludge Recirculation Grinder 6 VFD	E-Tap X PLC 26	
725VFD6601	Primary Heat Loop Pump 1 VFD	E-Tap X PLC 26	
725VFD6602	Primary Heat Loop Pump 2 VFD	E-Tap X PLC 26	
20VFD10501	Digested Sludge Pump 1 VFD	E-Tap X PLC 26	
20VFD10502	Digested Sludge Pump 2 VFD	E-Tap X PLC 26	
715VFD6406	FOG Waste Feed Pump 3 VFD	E-Tap X PLC 16	
715VFD6601	Secondary Heat Loop Recirculation Pump 1 VFD	E-Tap X PLC 16	
715VFD6602	Secondary Heat Loop Recirculation Pump 2 VFD	E-Tap X PLC 16	

Clean Water Services

ORT -2 FORM
Programming Checkout
Location, Project Name, Project

Start Date: _____

Item	Verified Initials	Actions
1		The PLC/SCADA Programmer has received all ORT1 sheets as shown in the ORT1 Master List and that each ORT1 sheet has been signed by contractor and approved by Owner.
2		The PLC/SCADA Programmer has received all signed loop drawing, circuit drawings, and vendor panel interconnect drawings associated with ORT1 sheets that are signed by contractor and the Owner.
3		The PLC/SCADA Programmer has a set of approved Control Loop Descriptions signed by the Owner.
4		PLC Program installed and SCADA workstation(s) are powered up and in service.
5		Process readings on SCADA screens match actual field/local measurements and status.
6		Alarms described in control loop descriptions activate in SCADA as designed.
7		Control System functions as designed and follows project Control Loop Descriptions.

PLC/SCADA programming accepted and ready for performance acceptance testing.

Date: _____

Programmer: _____ Date:_____

Owner: _____ Date:_____

SECTION 01770
CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 FINAL WALK THROUGH INSPECTION

A. When the Contractor has informed the Engineer that the Work has been completed, the Contractor shall participate in a final walkthrough inspection with the Owner and Engineer at which time the final punchlist will be prepared. The punchlist shall include all previously noted preliminary punchlist items and/or noncompliance or uncompleted work items. The Contractor shall complete and sign off all punchlist items with the Engineer.

1.02 FINAL CLEANUP

A. The Contractor shall promptly remove from the vicinity of the completed Work, all rubbish, unused materials, concrete forms, construction equipment, and temporary structures and facilities used during construction. Clean dust and debris from all new equipment, control cabinets, and electrical enclosures and components. In addition, clean dust and debris from existing equipment, control cabinets, and electrical enclosures and components affected by construction and in the following adjacent areas regardless of the source of contamination.

1. Solids Building.
2. Digester Complex 1.
3. Digester Complex 2.
4. Brown Grease Receiving facility.
5. Tunnels.

B. Final acceptance of the Work by the Owner will be withheld until the Contractor has satisfactorily performed the final cleanup of the Site.

1.03 CLOSEOUT TIMETABLE

A. The Contractor shall establish dates for equipment testing, acceptance periods, and onsite instructional periods (as required under the Contract). Such dates shall be established not less than 10 days prior to beginning any of the foregoing items, to allow the Owner, the Engineer, and their authorized representatives sufficient time to schedule attendance at such activities.

1.04 OPERATION AND MAINTENANCE MANUAL SUBMITTAL

A. The Contractor's attention is directed to the condition that 1 percent of the Contract Price will be retained from any monies due the Contractor as progress payments, if at the 75 percent construction completion point, the approved Operation and Maintenance Manuals complying with Section 01330, Submittal Procedures, has not been submitted. The aforementioned amount will be retained by the Owner as the agreed, estimated value of the approved Operation and Maintenance Manuals. Any such retention of money for failure to submit the approved Operation and Maintenance Manuals on or before the 75 percent construction completion point shall be in addition to the retention of any payments due to the Contractor. In any event, the approved Operation and Maintenance Manuals must be available to the Engineer prior to any equipment start up and system testing.

1.05 FINAL SUBMITTALS

A. The Contractor, prior to requesting final payment, shall obtain and submit the following items to the Engineer for transmittal to the Owner:

1. Written guarantees, where required.
2. Operation and Maintenance Manuals and instructions.
3. Maintenance stock items; spare parts; special tools.
4. Completed Record Documents (Drawings and Specifications).
5. Preconstruction, construction and post construction videos and photos.
6. Bonds for roofing, maintenance, etc., as required.
7. Certificates of inspection and acceptance by local governing agencies having jurisdiction.
8. Correction period bonds.
9. Releases from all parties (including private property owner's whose properties were used for yard or staging areas or were damaged) who are entitled to claims against the subject project, property, or improvement pursuant to the provisions of law.

1.06 FINAL APPLICATION FOR PAYMENT

A. Prior to the acceptance of the Work and final payment, the Owner will require the Contractor to submit a certificate in form substantially as follows:

1. "I (We) hereby certify that all Work has been performed and materials supplied in accordance with the Contract Documents for the above Work, and that:
   a. Not less than the prevailing rates of wages has been paid to laborers, workers and mechanics employed on this Work.
   b. All claims for material and labor and other services performed in connection with these Specifications have been paid.
   c. All monies due the State Industrial Accident Fund, the State Unemployment Compensation Trust Fund (ORS 279.510), the State Tax Commission (ORS 315.575, ORS 316.711 and ORS 316.714), hospital associations and/or others, (ORS 279.320), have been paid.
   d. All permit final inspections and approvals are complete.
   e. Contractor releases and discharges Clean Water Services of and from all liabilities, claims, obligations, and actions arising under the Contract.
   f. Contractor and the surety for this Contract shall defend, indemnify, and save Clean Water Services harmless from any liability or expense because of any claim on any Bond or any other claim related to the Contract or the Work."

1.07 CORRECTION OF DEFECTIVE WORK

A. The Contractor shall comply with the defective Work correction requirements contained in Article 15 of the General Conditions. The correction period shall begin upon the Substantial Completion of entire Project.

B. Replacement of earth fill or backfill, where it has settled below the required finish elevations, shall be considered as a part of such required corrective work, and any repair or resurfacing constructed by the Contractor which becomes necessary by reason of such settlement shall likewise be considered as a part of such required corrective work unless the Contractor shall have obtained a statement in writing from the affected private owner or public agency releasing the Owner from further responsibility in connection with such repair or resurfacing.

C. The Contractor shall make all repairs and replacements promptly upon receipt of written order from the Owner. If the Contractor fails to make such repairs or replacements promptly, the Owner reserves the right to do the Work and the Contractor and its surety shall be liable to the Owner for the cost thereof.

D. The Engineer will establish a Need for Warranty Service System with the Owner whereby the Owner will alert the Contractor of the need for warranty service during the 1-year Correction Period. The Contractor shall respond promptly to these requests. Should the Contractor fail to respond promptly, the Owner reserves the right to do the Work and the Contractor and its surety shall be liable to the Owner for the cost thereof.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01782
OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor shall furnish equipment operation and maintenance (O&M) information, instructions and data in accordance with this section and as required in the Technical Specifications of the Contract Documents.

B. O&M information, instructions and data shall be provided for each maintainable material and piece of equipment where applicable information may be grouped by specification division.

C. Operation and maintenance information, instructions, and data shall hereinafter be referred to as O&M Manual.

1.02 SUBMITTALS

A. Number the transmittal for and O&M Manual with the original root number of the approved Shop Drawing for the item shall be submitted through a collaboration internet web site as identified in Section 01330, Submittal Procedures.

B. Submit two final approved hardcopies.

C. Submit hardcopy O&M Manuals printed in color on 8-1/2-inch by 11-inch size heavy first quality paper with standard three-hole punching and bound in three-ring d-binders with rigid covers.

1. Provide binders with project name, specification section, equipment or material name, submittal version, submittal number, and date on front and spine of binder.
2. Provide table of contents.
3. Tab each section of manuals per the table of contents for easy reference with plastic-coated dividers.
4. Provide index for each manual for key drawings and tables.
5. Provide plastic sheet lifter prior to first page and following last page.
6. Reduce drawing or diagrams bound in manuals to 11-inch by 17-inch size.

D. Submit electronic version of O&M Manual in Adobe ".PDF" format.

1. All Adobe ".PDF" format files shall be bookmarked and searchable.
2. Electronic documents shall not be scanned.

E. O&M Manuals are required for:

1. All equipment with moving part or electrical components.
2. All equipment required by specifications to have an O&M Manual.

F. O&M Manuals shall include all of the following information where applicable:

1. Table of Contents.
2. The names, addresses, and telephone numbers of the manufacturer, nearest representative, and nearest supplier of parts.
3. Equipment function, normal operating characteristics, limiting operations.
4. Assembly, disassembly, installation, alignment, and adjustment instructions.
5. Operating instructions, including:
   a. Safety precautions.
   b. Startup, shutdown, and post shutdown.
   c. Normal operations.
   d. Emergency operations.
   e. Operational modes.
6. Preventative Maintenance instructions, including:
   a. Lubrication data, including recommended lubricants for specific temperature ranges; charts and diagrams showing lubrication points; lubricant types, grades, and capacities; and a lubrication schedule.
   b. Preventative maintenance plan and schedule.
7. Corrective Maintenance instructions, including:
   a. Troubleshooting guides and diagnostic techniques.
   b. Wiring diagrams and control diagrams, as applicable.
   c. Maintenance and repair procedures.
   d. Removal and replacement instructions.
   e. Any special tools required.
   f. Testing equipment required.
8. Outline, cross-section, assembly, and exploded view drawings.
9. Engineering data.
10. Wiring diagrams, Interconnection wiring diagrams.

11. All Test Data and Reports:
    a. Factory test reports.
    b. Field test reports and calibrations: Parameter reports off the instruments.
12. Provide a list of all parameters changed from factory default to current field settings for each piece of equipment.
13. Provide a list of recommended spare parts and predicted life of parts subject to wear. List out current pricing and factory part numbers for each item.
14. All part numbers and accessories being provided shall be highlighted and all extraneous information shall be removed or clearly struck out.
15. Warranty information.

G. Preliminary O&M Manual (POM):

1. Shall be submitted 60 days before startup.
2. Shall have owner approval 10 days before ORT-1.
3. This POM shall include a few imported items note below but not excuse any other required items:
    a. Equipment Data Sheets 95 percent filled out, serial number only item missing.
    b. All comments to be addressed from craft specific group and startup coordinator.
    c. All factory calibrations documents, Factory acceptance testing reports, and pump curves.
    d. ~~Spare parts and pricing information listed out pe Article Submittals, Paragraph F, Item 12.~~Spare parts and pricing information listed out per Article Submittals, Paragraph F, Item 13. Information submitted using the form provided at the end of this Section.[ADD. 3]
    e. Place holders for:
        1) Certificate of proper installation.
        2) Field Startup reports/Field Calibrations.
        3) Loop Drawings (updated as necessary).
    f. Bookmarks completed and working.

H. Final O&M Manual (FOM):

1. Include all items from Article Submittals, Paragraph F.
2. Shall have electronic copy to owner 14 days from completion of ORT-1.
3. Owner startup coordinator to review and give the approval to print hard copies.
4. Submit Hard copies of the O&M Manuals to Owner within 14 days of receiving authorization to print.

5. Deliver hard copies of the O&M Manuals to Owner's startup coordinator with transmittal letter.

1.03 EQUIPMENT DATA SHEETS

A. Provide equipment data sheets at the beginning of each equipment section of the O&M Manuals, summarizing the equipment manufacturer's maintenance instructions and recommendations. Equipment information sheets shall be completed using the included supplement "Equipment Information Sheets."

B. All data shall be entered directly into the Equipment Data Sheet and shall not reference the O&M Manual.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FIELD CHANGES

A. Following the acceptable installation and operation of an equipment item, the item's instructions and procedures shall be modified and supplemented by the Contractor to reflect any field changes or information requiring field data. Final Project acceptance and payment will be withheld by the Owner until final O&M Manual information reflecting field changes is submitted and accepted by the Owner.

3.02 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Equipment Information Sheet.
2. Recommended Spare Parts.[ADD. 3]

END OF SECTION

EQUIPMENT INFORMATION SHEET		Page
EQUIP. DESCRIPTION -	DATE INSTALLED	DATE STARTED
EQUIP. TAG -	EST. COST	EST. LIFE
EQUIP. LOCATION -	SPECIFICATION #	
MFR -		PHONE NUMBERS
ADDRESS		
VENDOR		

MAINTENANCE REQUIREMENTS	LUBE CODE		W	M	Q	S	A	HOURS

CODE	LUBRICANT TYPE	MANUFACTURER	CODE	LUBRICANT TYPE	MANUFACTURER
1					
2					
3					

EQUIPMENT INFORMATION SHEET			Page			
RECOMMENDED SPARE PARTS			ELECTRICAL NAMEPLATE DATA			
PART NO.	PART NAME	QUANTITY	EQUIP. Electric Motor			
			Manufacturer:			
			SERIAL NO.		ID NO.	
			MODEL NO.		FRAME NO.	
			HP	VOLT.	AMP.	HZ
			Phase	RPM	Service Factor	DUTY
			CODE	Insulation	Design	TYPE
			NEMA	Enclosure	Misc.	RATING
			MECHANICAL NAMEPLATE DATA			
			EQUIP.			
			Manufacturer:			
			SERIAL NO.		ID NO.	
			MODEL NO.		MOUNTING POS	
			HP	RPM	CAP	SIZE
			TDH	IMP.SZ	BELT NO.	Output Tor.
			PSI	NEMA	GEAR RATIO	

Recommended Spare Parts Information

Quantity	Part Number	Lubricant Type	Description	Price	Lead Time

Contact Information	
Company	
Name	
Phone #	
E-Mail	

SECTION 02200
SITE CLEARING

PART 1 GENERAL

1.01 DEFINITIONS

A. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

B. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 6 inches below subgrade.

C. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

D. Project Limits: Areas, as shown or specified, within which Work is to be performed.

E. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

F. Stripping: Removal of topsoil remaining after applicable scalping is completed.

1.02 SUBMITTALS

A. Action Submittals: Drawings clearly showing clearing, grubbing, and stripping limits.

1.03 QUALITY ASSURANCE

A. Obtain Engineer’s approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.04 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 0.1-acre.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.02 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation 5 feet beyond top of cut slopes.
2. Trench Excavation: 4 feet from trench centerline, regardless of actual trench width.
3. Structures: 15 feet outside of new structures.
4. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 CLEARING

A. Clear areas within working limits.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing to within 6 inches of ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.04 GRUBBING

A. Grub areas within work limits.

B. Grub stumps of trees that are designated for removal. Designated trees are shown on plans.

3.05 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.

B. Scalp areas within work limits.

3.06 STRIPPING

A. Do not remove topsoil until after scalping is completed.

B. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

C. Stockpile strippings, meeting requirements of Section 02316, Fill and Backfill, for topsoil, separately from other excavated material.

3.07 SALVAGE

A. Saleable log timber may be sold to Contractor's benefit. Promptly remove from Project Site.

B. Sod with commercial value may be sold to Contractor's benefit. Promptly remove from Project Site.

3.08 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite.
2. Burning of debris onsite will not be allowed.
3. Woody debris may be chipped. Chips may be sold to Contractor's benefit or used for landscaping onsite as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and not support combustion. Maximum dimensions of chipped material used onsite shall be 1/4-inch by 2 inches. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris.
4. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite.
2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

SECTION 02205
INSTRUMENTATION AND MONITORING

PART 1 GENERAL

1.01 SUMMARY

A. The Work covered in this section consists of conducting visual inspection, and providing, installing, monitoring, maintaining, and removing instrumentation required to monitor ground and facility movements in the vicinity of the Work.

B. The Contractor shall institute a monitoring program to identify movements and settlements that may be detrimental to existing facilities. At a minimum this shall include monitoring points shown on the Drawings. Additional structures and locations may be identified by the Engineer during the preconstruction meeting or throughout the construction process.

C. Instrumentation shall be installed to measure structure and ground movements. Monitoring will include measurements of selected ground, wall, and slab locations. Instrumentation shall be installed with the primary purpose of monitoring temporary effects that may occur during construction. Contractor shall be responsible for providing, installing, monitoring, maintaining, and removing monitoring equipment and shall be responsible for and shall follow the instructions and requirements of this specification for the installation, calibration, and testing of all measuring instruments and equipment. This Work shall be carried out in coordination with Engineer. The Contractor shall inform Engineer at least 5 days prior to undertaking establishment of reference points and monitoring points and shall make allowances in the construction program for delay which may arise on account of the installation, monitoring, and maintenance of these monuments. Contractor’s plan and proposed frequency for recording data shall be approved prior to excavation or ground improvement.

1.02 DEFINITIONS

A. Movement Monitoring Points: Similar instruments as settlement points; however, movement monitoring points are used to measure vertical and horizontal movement of the ground or portions of structures.

B. Settlement Points: Instruments used to measure vertical movement of the ground surface or portions of structures. Settlement monitoring points may include roadway survey pins or other survey targets affixed to structures. Also referred to as “monitoring hubs” or “hubs.” Settlement monitoring points include fixed markers or targets.

C. Survey Control: A system of precise field measurements of the types and kinds specified herein, utilizing suitable methods and equipment for determination of elevations, coordinates, and distances for performing monitoring point readings.

1.03 SUBMITTALS

A. Action Submittals:

1. Detailed survey monitoring plan showing:
   a. Monitoring point locations, type of monitoring device used, survey control, and facilities being monitored.
   b. Product data for each type of monitoring device.
2. Movement measurements showing:
   a. Recorded data for each monitoring device, including movement, date, and time data was recorded. Data shall be recorded and submitted regardless of whether any movement or distress was measured or identified.
   b. Reduced results indicating total vertical movement, total horizontal movement, horizontal and vertical movement trends, and plots of data trends. Total horizontal and vertical movements shall be relative to base readings.
   c. Submit records and plots:
      1) Once every 2 weeks during construction of Digester 3 shoring system.
      2) Once every 2 weeks during excavation of Digester 3.
      3) Monthly during any period when excavations greater than 8 feet deep are present at the Site.
      4) Weekly during periods when detrimental movements or settlements are noted.
      5) Once for survey measurements when backfill work is complete.

1.04 QUALITY CONTROL

A. Protection and Maintenance of Monitoring Points: The Contractor shall take all necessary precautions to preserve and protect all monitoring points. Monitoring points shall be installed in areas where movements are most likely to occur as designated by the Engineer. Contractor shall install temporary protective barriers as necessary to maintain, preserve, and protect and assure that all points remain undisturbed from construction work including working equipment and other disturbances that could impact the accuracy of the readings. Contractor shall assure that all monitoring points remain in good working order after installation.

B. Labeling and Marking of Monitoring Points: All monitoring points shall be labeled with a reference number. The reference number shall be stamped into a small monument that shall be drilled and grouted to concrete surface near the reference point, set in top of concrete monument, or it shall be painted or otherwise labeled with a permanent marking system at the location where readings or measurements are taken. All labeling shall be permanent using methods and materials to be agreed upon with the Engineer.

C. Accuracy of measurements, readings, or monitoring shall be sufficient to detect movement prior to causing damage to existing structures, as indicated in the Contractor's monitoring plan, but at least to the nearest 0.01-foot horizontally and vertically.

1.05 QUALIFICATIONS

A. Contractor shall employ a Professional Licensed Surveyor registered in the State of Oregon to establish and provide oversight of surveys required to monitoring settlement and movement monitoring points. Licensed surveyor shall have performed similar settlement monitoring work in a similar capacity for a minimum of 5 years.

PART 2 PRODUCTS

2.01 GENERAL

A. Survey Equipment: All surveying equipment used in conjunction with the monitoring of instrumentation including measuring tapes and devices, precise levels and theodolites shall be maintained and calibrated as required by the manufacturer of equipment. Certificates of calibration for all equipment shall be submitted to the Engineer and approved by Engineer prior to conducting the Work.

B. Permanent Reference Points: Permanent reference points consisting of benchmarks (PBMs) shall be installed at the locations agreed to by the Contractor and Engineer. At least three PBM reference points shall be installed surrounding the Site at the approximate locations shown and shall be fixed into stable ground that is sufficiently distant from the structures so that these PBMs are isolated from influence of construction and compression of natural sediments that underlie the area of work. These PBMs shall be established and initial readings obtained prior to beginning the Work at the Site. The levels for all PBMs shall be checked by survey methods every 3 months or more often if needed to track and record movement associated with construction activities.

PART 3 EXECUTION

3.01 CONDITION ASSESSMENT

A. The Contractor shall perform a detailed examination of each existing structure and utility adjacent to the proposed shoring before any shoring or ground improvement construction is started. The survey shall include scale drawings showing location and size and extent of existing cracks and structural distress. The condition survey shall include photographic and/or video records to document existing conditions.

3.02 MONITORING POINTS

A. Contractor shall install movement monitoring points in locations as indicated on the Drawings or as directed by the Engineer in the field.

B. Elevations and coordinates of monitoring points shall be surveyed with an accuracy of no worse than the nearest 0.01-foot horizontally and vertically. The datum used shall preferably require only one setup of the level, and leveling shall be closed back to the datum.

3.03 INSTRUMENTATION RECORDS

A. Commissioning and Base Readings:

1. After installation of all monitoring points, the functioning of each instrument shall be demonstrated to the Engineer, including the recording of measured values using the appropriate readout devices. All instrumentation including reference points shall be installed before any earthwork starts. As part of the commissioning, three sets of readings shall be taken and compared. If there are significant differences or anomalies, then further readings shall be taken until there are no significant differences in the readings between data sets. Once three sets of comparable readings have been taken, these shall be averaged to form the base readings, representing conditions before construction starts.
2. In cases where additional monitoring points are installed during construction, three sets of readings shall be taken in quick succession and the results compared. These results shall be used to provide base readings in a manner to be agreed upon with the Engineer.

B. General Information on All Records:

1. All records of instrumentation, either installation, readings, or monthly summaries, shall contain the following information:
   a. Project name.
   b. Contract name and number.
   c. Instrument reference number and type.
   d. Dates of installation, reading or summary.
   e. Times of installation or reading.
   f. Chainage and Offset (or coordinates if appropriate).
   g. Personnel responsible for readings.
   h. Relevant comments or remarks.
   i. Provide precise elevations and offsets of all readings in accordance with the accuracy defined or required.

C. Installation Records and Reports: The Contractor shall prepare an installation record sheet for each monitoring point installed. The format of the sheet shall be prepared by the Contractor and submitted to the Engineer for approval before installation commences. The record sheet shall include the information as specified hereinbefore.

3.04 FREQUENCY OF SURVEY MEASUREMENTS, READINGS, AND MONITORING

A. Survey measurements shall be taken at intervals shown in the monitoring plan, but not less frequent than that specified herein.

B. Before Work Starts: At least three sets of measurements shall be taken for each monitoring points. Survey measurements shall be from at least three separate days.

C. Survey of Primary Movement Monitoring Points shall be taken at the following maximum intervals:

1. During Construction of Digester 3 Shoring System:
   a. Survey each monitoring point located within 100 feet of work activities once weekly as follows:
      1) Complete surveys on the same day of each week.
2. During Excavation for Digester 3:
   a. Survey each movement monitoring point at each 2 feet of excavation depth beyond the first 8 feet of excavation.
   b. Complete daily surveys during any condition that increases the ground water level or soil moisture content, such as floods, precipitation exceeding 2 inches in 24 hours, or leaking pipes.
3. During Periods When Detrimental Movements or Settlements are noted: Measurements shall be taken daily including weekends and holidays.

3.05 DETRIMENTAL MOVEMENTS OR SETTLEMENTS

A. Recording of settlements and movements shall be in strict accordance with the movement monitoring plan. Work shall be stopped immediately and the causes of detrimental movements be ascertained if:

1. Damage is noted on structures adjacent to excavation areas.
2. Total settlements of an adjacent structure is noted to be 3/8-inch or larger.
3. Digester secant pile shoring movements are noted to be 5/8-inch or larger.
4. There is a trend or rate of change of any settlement or movement that will indicate the above maximums will be exceeded.
5. Work is directed to stop by the Engineer due to other detrimental effects or factors.

B. Should verified measurements of any monitoring point indicate that deflections are occurring, or have occurred that exceed the Allowable Deflection Limits, all related project work shall stop. The Contractor shall determine its preferred Corrective Action and immediately. The causes of detrimental movements or excessive settlements must be identified by the Contractor. Corrective measures must be proposed to and approved by the Engineer before further Work.

C. After implementing the approved corrective action, the Contractor shall verify success of the corrective action by completing additional surveys of the monitoring points. If the verification surveys indicate that the corrective action was not successful or if measurements show increased deflection, then the Contractor shall cease all related operations contributing to the movements, if not already ceased. Submit a revised Corrective Action Plan to resolve the ground movements. Repeat the above process until results are to the satisfaction of the Engineer.

D. Work shall not recommence until results acceptable to the Engineer have been achieved. This may include, at the discretion of the Engineer, restoring the deflected element(s) to their original position, demonstrating that deflections have been controlled and are not progressing, and modifying construction methods to avoid further unacceptable deflections.

3.06 PROTECTION AND MAINTENANCE

A. Repair or replace damaged, missing, or obstructed monitoring points as required within 12 hours of detection of damage. Repair damage to any monitoring points at no additional cost.

3.07 REMOVAL OF INSTRUMENTS

A. Remove all monitoring points and monuments immediately upon finishing construction.

END OF SECTION

SECTION 02220
DEMOLITION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): Guideline K, Containers for Recovered Non-flammable Fluorocarbon Refrigerants.
2. American National Standards Institute (ANSI): A10.6, Safety Requirements for Demolition Operations.
3. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
   a. Part 61—National Emission Standards for Hazardous Air Pollutants.
   b. Part 82—Protection of Stratospheric Ozone.
   c. Part 273—Standards for Universal Waste Management.
4. Occupational Safety and Health Administration (OSHA), U.S. Code of Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety and Health Regulations for Construction.

1.02 DEFINITIONS

A. ACM: Asbestos-containing material.

B. Demolition: Dismantling, razing, destroying, or wrecking of any fixed building or structure or any part thereof. Demolition also includes removal of pipes, manholes tanks, conduit, and other underground facilities, whether as a separate activity or in conjunction with construction of new facilities.

C. Modify: Provide all necessary material and labor to modify an existing item to the condition indicated or specified.

D. Relocate: Remove, protect, clean and reinstall equipment, including electrical, instrumentation, and all ancillary components required to make the equipment fully functional, to the new location identified on the Drawings.

E. Renovation: Altering a facility or one or more facility components in any way.

F. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste; such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

G. Universal Waste Lamp: In accordance with 40 CFR 273, the bulb or tube portion of an electric lighting device, examples of which include, but are not limited to, fluorescent, high-intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps.

H. Universal Waste Thermostat: A temperature control device that contains metallic mercury in an ampule attached to a bimetal sensing element, and mercury-containing ampules that have been removed from these temperature control devices in compliance with the requirements of 40 CFR 273.

1.03 SUBMITTALS

A. Informational Submittals:

1. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started.
2. Submit copies of any notifications, authorizations and permits required to perform the Work.
3. Copies of reports and other documentation required for abandoning wells.

1.04 REGULATORY AND SAFETY REQUIREMENTS

A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.

B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor’s safety requirements shall conform to ANSI A10.6.

C. Furnish timely notification of this demolition project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.05 DEMOLITION/RENOVATION PLAN

A. Demolition/Renovation Plan shall provide for safe conduct of the Work and shall include:

1. Detailed description of methods and equipment to be used for each operation.
2. The Contractor's planned sequence of operations, including coordination with other work in progress.
3. Procedures for removal and disposition of materials specified to be salvaged.
4. Disconnection schedule of utility services.

B. Include statements affirming Contractor inspection of the existing roof deck, floors, walls, and framing members, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work.

1.06 SEQUENCING AND SCHEDULING

A. The Work of this specification shall not commence until Contractor's Demolition/Renovation Plan has been approved by Engineer.

B. Include the Work of this specification in the progress schedule, as specified in Section 01324, Construction Schedule.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

A. Utilities and Related Equipment:

1. Notify Owner or appropriate utilities to turn off affected services at least 2 weeks before starting demolition activities.
2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
3. When utility lines are encountered that are not indicated on the Drawings, notify Engineer and Owner prior to further work in that area.
4. Remove meters and related equipment and deliver to a location as determined by the Owner.

5. Provide a permanent leak-proof closure for water and gas lines.
6. Plug sewer lines with concrete to a minimum plug length of 2 feet to prevent groundwater infiltration.

B. Groundwater Observation Wells: Abandon the groundwater observation wells in test borings in accordance with OAR 690-240 requirements. Submit copies of all reports and other documentation required to be submitted to OAR. Abandon wells that will be within the limits of an excavation before excavation begins.

C. Paving and Slabs:

1. Remove, Grind, and Sawcut asphaltic concrete paving as indicated on the Drawings.
2. Provide neat sawcuts at limits of pavement removal as indicated.

D. Masonry: Sawcut and remove masonry so as to prevent damage to surfaces to remain. Where new masonry adjoins existing, the new Work shall abut or tie into the existing construction as indicated.

E. Concrete:

1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished Work, and the remaining concrete is sound.
2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on the Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16-inch. Rebar and small embeds at existing concrete may be required to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on the Drawings.

F. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include: Fill holes and depressions left as a result of removals in existing concrete or supports with an approved patching material, applied in accordance with the manufacturer's printed instructions.

G. Electrical:

1. Cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4-inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on the Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.
4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.
5. Raceways and cabling not scheduled for reuse.
6. Inaccessibly Concealed: Cut off and abandon in place.
7. Exposed or Concealed Above Accessible Ceilings: Remove.
8. Raceways and Cabling Scheduled for Future Use: Cap or seal and tag.
9. Relocating Equipment: Extend existing wiring or run new wiring from the source.
10. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
11. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
12. Provide new typewritten panelboard circuit directory cards.

H. Universal Waste Lamps and Thermostats: Manage, contain, package, and label in strict accordance with 40 CFR 273.

I. Air-Conditioning Equipment: Recover all refrigerants prior to removing air-conditioning equipment and dispose of as specified in Paragraph 3.09, Ozone Depleting Substances.

3.02 PROTECTION

A. Dust and Debris Control:

1. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
2. Vacuum and dust the Work area daily.
3. Sweep pavements, including magnetic sweeping as often as necessary or at a minimum weekly to control the spread of debris that may result in foreign object damage potential to vehicular traffic.

B. Traffic Control Signs: Where pedestrian and driver safety is endangered in the area of removal Work, use traffic barricades with flashing lights.

C. Existing Work:

1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.
5. Do not overload pavements to remain.

D. Weather Protection: For portions of the building scheduled to remain, protect building interior and materials and equipment from weather at all times. Where removal of existing roofing is necessary to accomplish the Work, have materials and workmen ready to provide adequate and temporary covering of exposed areas so as to ensure effectiveness and to prevent loss.

E. Trees: Protect trees within the Site that might be damaged during demolition and are indicated to be left in place, by a 4-foot-high, polyethylene or polypropylene safety fence. The fence shall be securely erected a minimum of 5 feet from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the Work shall be replaced in kind, as approved by the Engineer.

F. Facilities:

1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.
2. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
3. Protect all facility elements not scheduled for demolition.
4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.

G. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
2. Provide temporary barricades and other forms of protection to protect Owner’s personnel and the general public from injury due to demolition Work.
3. Provide protective measures as required to provide free and safe passage of Owner’s personnel and the general public to occupied portions of the structure.

3.03 BURNING

A. The use of burning at the Site for the disposal of refuse and debris will not be permitted.

3.04 RELOCATIONS

A. Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Clean all items to be relocated prior to reinstallation, to the satisfaction of Engineer. Repair items to be relocated which are damaged or replace damaged items with new undamaged items as approved by Engineer.

3.05 BACKFILL

A. Do not use demolition debris as backfill material.

B. Fill excavations, open basements and other hazardous openings to existing ground level or foundation level of new construction in accordance with Section 02316, Fill and Backfill.

3.06 TITLE TO MATERIALS

A. All salvaged equipment and materials will remain the property of Owner.

B. Title to equipment and materials resulting from demolition is vested in the Contractor upon approval by Engineer of Contractor’s Demolition/Renovation Plan, and the resulting authorization by Engineer to begin demolition.

3.07 DISPOSITION OF MATERIAL

A. Do not remove equipment and materials without approval of Contractor’s Demolition/Renovation Plan by Engineer.

B. Salvage equipment and material to the maximum extent possible.

C. Remove salvaged items designated as the property of Owner in a manner to prevent damage.

D. Repair or replace, at the discretion of Engineer, items damaged during removal or storage.

E. Deliver salvaged items that are designated as the property of Owner to a storage site as directed on the Site.

3.08 REUSE OF MATERIALS AND EQUIPMENT

A. Remove and store materials and equipment listed in Article Title To Materials to be reused or relocated to prevent damage, and reinstall as the Work progresses.

B. Properly store and maintain equipment and materials in same condition as when removed.

C. Store equipment and material designated to be reused in a location designated by Owner.

D. Equipment and material designated to be reused shall be cleaned, serviced and checked for proper operability before being put back into service.

E. Engineer will determine condition of equipment and materials prior to removal.

3.09 SPECIALIZED SALVAGE

A. Ozone Depleting Substances (ODS):

1. Class I and Class II ODS are defined in Section 602(a) and Section 602(b), of The Clean Air Act. Prevent discharge of Class I and Class II ODS to the atmosphere. Place recovered ODS in cylinders meeting AHRI Guideline K suitable for the type ODS (filled to no more than 80 percent capacity) and provide appropriate labeling.
2. Dispose of all Class I and Class II ODS refrigerants in accordance with the Clean Air Act Amendment of 1990.
3. Products, equipment and appliances containing ODS in a sealed, self-contained system (e.g., residential refrigerators and window air conditioners) shall be disposed of in accordance with 40 CFR 82.

3.10 UNSALVAGEABLE MATERIAL

A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of in the following manner and location.

1. Sanitary landfill off of the Site.

B. Combustible material shall be disposed of in the sanitary fill area located off the Site.

C. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.11 CLEANUP

A. Debris and rubbish shall be removed from basement and similar excavations. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

SECTION 02240
DEWATERING

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section covers activities necessary to control, handle, treat, and dispose of groundwater and surface water, and all other water that may be encountered, as required to construct utilities and structures.

1.02 SUBMITTALS

A. Informational Submittals:

1. Water control plan.
2. Well permits.
3. Discharge permits.
4. Submit Daily: Location and number of well points in operation; water levels in all well points, monitoring wells; discharge rates; total flow and discharge volumes; and a description of any problems with the dewatering system and any remedial actions implemented.

1.03 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system, including extraction wells, piezometers and observation wells, conveyance piping, pumps, sedimentation control facilities, discharge locations, and other components necessary to facilitate sufficient dewatering.
3. Design calculations demonstrating adequacy of proposed dewatering systems and components.
4. Water control plan shall be signed and sealed by a professional Engineer in the State of Oregon.

B. If system is modified during installation or operation, revise or amend and resubmit Water Control Plan. Do not commence excavation until revised and amended Water Control Plan has been received and approved.

C. Review of Contractor's Water Control Plan (original and any subsequent revisions) shall be only for compliance with specific stated requirements for its content as specified and not for accuracy of content or for adequacy of the Plan, both of which shall be solely the responsibility of Contractor.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. For the Digester 3 excavation, continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

B. For completed work where failure to control water could result in deterioration or damage requiring rework or remediation, continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

C. Remove and control water during periods when necessary to properly accomplish Work.

3.02 WATER POLLUTION CONTROL

A. Comply with requirements of Section 01560, Temporary Environmental Controls, for stormwater flow and surface runoff.

3.03 SURFACE WATER CONTROL

A. Divert sanitary sewage and non-storm waste flow interfering with construction and requiring diversion to sanitary sewers.

B. Prior to commencing excavation and construction, obtain Owner's agreement with detailed plans showing procedures intended to handle and dispose of stormwater, groundwater, and dewatering pump discharges.

C. Do not dispose of volatile or liquid wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

D. Remove surface runoff controls when no longer needed.

E. Direct surface runoff away from the work areas before water enters excavation.

3.04 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, including artesian and perched groundwater and until backfilled to final grade.

B. For digester facility, dewatering systems may include extraction wells or well points, and other equipment and appurtenances installed either inside or outside limits of excavation and sufficiently below lowest point of excavation, or to maintain specified groundwater elevation.

C. Design and Operate Dewatering Systems:

1. To prevent loss of ground as water is removed.
2. To allow required compaction of subgrade.
3. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
4. To relieve artesian pressures and resultant uplift of excavation bottom.
5. To allow excavation and construction of structures free of water.
6. To prevent instability of faces of excavation.

D. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

F. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

3.05 MONITORING FLOWS

A. Monitor volume of water pumped each calendar day from wells, well points, and excavations. Also monitor volume of water introduced each day into excavations for performance of Work. Monitor flows using measuring devices acceptable to Engineer.

3.06 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. Remove and dispose of solids from treatment facilities per federal, state, and local regulations and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.07 SYSTEM DECOMISSIONING AND REMOVAL

A. Dewatering systems and monitoring well decommissioning shall be according to appropriate sections of OAR 690-200, OAR 690-220, and OAR 690-240.

END OF SECTION

SECTION 02260
SHORING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies requirements for sheeting, shoring, and bracing of trenches and excavations other than the secant pile shoring system to be used for the Phase 6B Digester, that are required for construction of yard piping and associated facilities. These sheeting, shoring, and bracings are hereinafter collectively referred to as “shoring” or “excavation support.” Contractor shall not perform excavation that is not in accordance with the submitted and accepted Shoring Plan and Excavation Plan per Section 02315, Excavation, or an updated and accepted Plan as required to address site conditions.

B. Requirements for secant pile shaft excavation support for the Phase 6B Digester are provided in Section 02265, Secant Pile Excavation Support System.

1.02 SUBMITTALS

A. Informational Submittals:

1. Excavation support plan.
2. Trench excavation support plan.
3. Movement measurement and data and reduced results indicating movement trends.
4. Review of excavation support plan, and trench excavation plan shall be only for compliance with topics included, preparation, and similar specified requirements, and not for the accuracy or the adequacy of the plans or facilities, which together with all other matters of health and safety shall be solely the responsibility of Contractor.

1.03 QUALITY ASSURANCE

A. Perform surveys to monitor movements of existing structures and facilities located within 100 feet of excavation.

B. Perform surveys by professional land surveyor licensed in the State of Oregon.

C. The Contractor shall provide access for the Owner or Owner’s Representative to perform supplemental survey or to evaluate any portion of the sheeting, shoring, bracing, or supported soil or infrastructure.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

B. The Contractor shall be responsible for execution of the Excavation Support Plan and protecting workers, the public, and surrounding infrastructure from injury or damage from Contractor's activities.

C. Adequately support excavation for excavation and trenches and structures to meet the submitted and accepted Excavation Support Plan and the applicable requirements in the current rules, orders, and regulations. Excavation shall be adequately shored, braced, and sheeted so that the earth will not slide or settle and so that existing structures and all existing and new pipe and structures will be fully protected from movement or damage. Vehicles, equipment, and materials shall be kept far enough from the excavation to prevent instability of the trench sidewalls and adjacent surfaces as described in the Excavation Support Plan.

D. The construction of sheeting, shoring, and bracing shall not disturb the state of soil adjacent to the trench or below the excavation bottom, where such disturbance leads to movement or damage to existing utilities, infrastructure, or existing pavement or results in a reduction in lateral support of facilities.

E. In areas where the limits of excavation is located within 10 feet from existing pavement or infrastructure, Contractor shall not excavate more than 5 feet deep without placing shoring inside the excavation. All caving or sloughing of soils occurring within the first 5 feet of depth shall be repaired immediately by the Contractor at the Contractor's expense. Repair shall meet the requirements of this section. From a depth of 5 feet down to the bottom of the excavation, Contractor shall excavate inside the shoring system, keeping the shoring elements in full contact with and tight against the adjacent excavation sidewall soils preventing movement.

F. Contractor shall immediately fill any voids between the excavation sidewall and the outside of shoring with backfill material at all stages of construction.

G. If caving or sloughing of soils occurs, or if adjacent pavement becomes damaged due to excavation, Contractor shall immediately stop work and fill the voids created by caving or sloughing. Prior to continuing excavation, modify means and methods to prevent further damage to adjacent pavement or infrastructure.

H. Installation of shoring and sheeting using vibratory and/or impact hammers is not allowed.

3.02 EXCAVATION SUPPORT PLAN AND TRENCH EXCAVATION PLAN

A. Prepare excavation support and trench excavation plan addressing following topics:

1. Details of shoring, bracing, sloping, or other provisions for protection of existing facilities, finished products, and worker protection from hazards of caving ground.
2. Design assumptions and calculations.
3. Methods and sequencing of installing excavation support.
4. Proposed locations of stockpiled excavated material.
5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
6. Anticipated difficulties and proposed resolutions.
7. Excavations exceeding 20 feet in depth must be designed, signed, and sealed by a licensed professional engineer.

3.03 MOVEMENT MONITORING PLAN

A. See Section 02205, Instrumentation and Monitoring, for requirements of movement monitoring plan.

3.04 REMOVAL OF EXCAVATION SUPPORT

A. The support for excavation shall remain in place during the structure backfilling. During the backfilling of the pipeline or structure, the shoring, sheeting, and bracing shall be carefully removed in stages so that there shall be no voids created and no caving, lateral movement, loosening, or flowing of the sidewalls or subsoils toward the backfill zones and so that compacted backfill material gets placed against native undisturbed soils. Shoring elements shall be removed without causing damage to the approved backfill material. Fill any void left by trench shoring system with CLSM.

B. Remove excavation support in a manner that will maintain support as excavation is backfilled.

C. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.

D. Remove excavation support in a manner that does not leave voids in the backfill.

3.05 TRENCHES

A. Provide trench excavations exceeding 4 feet in depth with adequate safety systems meeting the requirements of the Oregon OSHA and other applicable state and local construction safety orders, and federal requirements.

END OF SECTION

SECTION 02265
SECANT PILE EXCAVATION SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the requirements for the installation of the Contractor designed secant pile excavation support systems for Digester 3 using temporarily cased hole drilling equipment.

B. Requirements for excavation support for trenches and facilities using excavation support systems not consisting of secant piles are provided in Section 02260, Shoring.

1.02 QUALITY ASSURANCE

A. Reference Standards: This section incorporates by reference the latest revision of the following documents. These references are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

1. American Petroleum Institute (API): 13B: Field Testing Water-Based Drilling-Fluids.
2. ASTM International (ASTM):
   a. C39, Standard Test Methods for Compressive Strength of Cylindrical Concrete Specimens.
   b. C138-17a, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
   c. C143, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   d. C1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
   e. D3740: Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
   f. D5882: Low Strain Impact Integrity Testing of Deep Foundations.
3. International Association of Foundation Drilling (Association of Drilled Shaft Contractors) (ADSC): Drill Shaft Inspector’s Manual.

B. Qualifications:

1. Secant Pile Contractor:
   a. Experienced in completing a minimum of three secant pile construction projects using the same pile drilling methods proposed for this Work, where the secant pile portion of the Work was performed and achieved Substantial Completion within the last 7 years. The secant pile contractor shall demonstrate experience of the firm with all three criteria items provided below:
      1) Construction of secant piles to a depth of 45 feet or greater.
      2) Excavation within secant pile supported shaft to a depth of 25 feet or greater.
      3) Construction of secant pile below groundwater.
      4) Using acoustical measuring device, or other proprietary pile installation monitoring system to measure verticality and the dimensional accuracy of the secant piles.
   b. Slurry Manufacturer's Onsite Technician: Trained by the slurry manufacturer with a minimum of 2 years' construction experience working with slurries.
   c. Pile Integrity Testing Consultant: Independent consultant with at least 2 years' experience in similar testing including performing testing and analyzing data. The testing shall be performed by a technician with at least 1 year experience in integrity testing. The interpretation of the records shall be performed by an engineer with at least 2 years' experience in integrity testing.

1.03 SUBMITTALS

A. Qualifications:

1. Provide detailed qualifications for:
   a. Secant Pile Contractor.
   b. Slurry Manufacturer's Onsite Technician.
   c. Independent Materials Testing Firm.
   d. Pile Integrity Testing Consultant.

B. Secant Pile Shaft Information and Narrative Plan (Plan):

1. At least 20 days prior to the start of secant pile construction, submit an Information and Narrative Plan that describes the proposed equipment and method of construction of secant pile shafts.

2. Remedial action plan(s) for repairing or replacing defective or otherwise nonconforming secant piles.
3. Groundwater Control Work Plan.

C. Project Records:

1. During secant pile wall construction, submit a daily drilled shaft record in a report format within 24 hours of completing each shaft installation. The daily record shall include the following information:
   a. Project Name.
   b. Name of Secant Pile Contractor, superintendent, and driller.
   c. Secant pile shaft name (Durham Digester 3).
   d. Secant pile identification number(s) consistent with the design document numbering.
   e. Ground surface elevation and top of secant pile elevation and coordinates.
   f. Secant pile length and diameter.
   g. Secant pile overlap.
   h. Theoretical volume of concrete required per drilled pile.
   i. Actual volume of concrete placed for each dilled pile.
   j. Records of obstructions encountered and resolution of obstruction removal or relocation of drilled pile.
   k. Unusual occurrences during drilling and backfill of pile.
   l. Record of re-drilling (if required).
   m. Concrete batch plant tickets.
   n. Slurry testing.
   o. Reinforcing placement.
   p. Concrete test results.
2. Record Drawings.

1.04 DEFINITIONS

A. Defect or Defective Pile:

1. The secant pile wall is an integral part of the completed work and its construction and integrity are paramount. The following will be considered defects and require satisfactory repair or replacement of defective piles:
   a. Exceeds specified vertical tolerances.
   b. Less than minimum wall thickness or interlock between piles.
   c. Less than specified minimum concrete strength.
   d. Cracks greater than 1/16 inch.

e. Exceeds specified leakage.
f. Voids or cavities.
g. Concrete contamination or noncemented materials or soil intrusion.
h. Honeycombing.
i. Slurry debris and deposits in interlock preventing bonding of piles.
j. Interior surface protrusions or bulges if they negatively affect or impact construction of the digester or placement of fill between digester and secant system.
k. Inability to drill through existing piles to create interlock.
l. Failure of adjacent piles to interlock.
m. Interior diameter of secant pile shaft less than dimension indicated on the Drawings.

B. Digester 3 Excavation: Main excavation inside the secant pile wall.

C. Obstructions: A specific object (including boulders, logs, and manmade objects) encountered during secant pile construction which prevents or hinders the advance of the drill tooling, such that the advancement rate is significantly reduced relative to the rate of advance for the portion of the Work in the same geologic unit and same type of pile that does not contain the obstruction.

D. Primary Secant Pile: Primary secant piles are the alternating, unreinforced piles.

E. Secant Pile Shaft, Boring, Pile Hole: Secant pile's shaft, boring or hole.

F. Secant Pile Wall: Concrete wall that is formed with overlapping cast-in-place concrete piles. The concrete is placed using the tremie method, below existing grade in bored holes that are stabilized with drilling slurry and/or temporary casing.

G. Secondary Secant Pile: Secondary secant piles are the alternating piles, drilled between adjacent Primary Secant Piles.

H. Temporary Casing: Casing installed to facilitate secant pile construction that is removed during or shortly after concrete placement.

1.05 SECANT PILE SHAFT INFORMATION AND NARRATIVE PLAN

A. The Secant Pile Shaft Information and Narrative Plan (Plan) shall be prepared by the secant pile system Contractor and shall include the following calculations along with the layout drawings (Item 7) shall be prepared and stamped by a Professional Engineer licensed in the State of Oregon.

1. Data on all equipment necessary for the Work.
2. Background of the drilling equipment and its successful use on other projects with similar soil conditions and installation requirements.
3. Qualifications and experience of drilling equipment operator(s) and the drilling Contractor's onsite personnel.
4. Information that shows that the drilling equipment has sufficient capacity to drill in the Project's soil conditions and through previously installed secant piles to create the interlocking overlap.
5. An overall sequence of construction of the secant piles, ring beam, groundwater control, excavation, interior cast-in-place concrete structure, and backfilling.
6. Sequence of the installation of various secant piles forming the shaft wall including maximum time limits for drilling overlapping pile holes.
7. Layout drawing(s) and calculations including:
    a. Pile layout plan.
    b. Diameter of piles.
    c. Sequence of pipe installation using numbers indicated on the Contractor's approved submittal.
    d. Guide wall and ring beam details, if either is used. Guide walls and/or ring beam shall be designed to accommodate the existing electrical duct bank located east of Digester 3. The duct bank cannot be moved and the electrical system cannot be de-energized. Remove the upper portion of the secant system including the guide wall and ring beam in accordance with requirements provided on the Drawings.
    e. Wall penetration details.
    f. Reinforcement details, including requirements for reinforcing splices if applicable.
    g. Required minimum 28-day unconfined compressive strength of concrete.
    h. Calculations demonstrating the adequacy of the secant system to withstand anticipated earth and surcharge loading.

8. Demonstrate coordination with other systems including pipeline penetrations, existing structures, new and previously constructed structures, dewatering systems, landscaping, drain lines, etc.
9. Methods of excavation of the pile holes, including methods and procedures to assure the alignment, stability of pile holes, and clean bottom of pile holes.
10. Method and locations of slurry preparation, site distribution, reclamation, and disposal.
11. Qualifications of slurry designer and slurry manufacturer's onsite technician.
12. Slurry designs, including mix composition, tests to be performed, test methods and frequency of monitoring and testing to comply with requirements specified herein and manufacturer's recommendations.
13. Method of monitoring deviation from vertical of pile holes during excavation, and details of proposed corrective measures to be implemented if necessary.
14. Method(s) for cleaning pile holes, slurry deposit filled gaps, and equipment and method for checking and proving the cleanliness of excavated pile hole bottoms and soundness of foundation material, prior to placing concrete.
15. Method of installing and securing reinforcing.
16. Method of placing concrete and handling displaced slurry.
17. Method(s) for handling and stopping all flowing leaks in the secant pile wall prior to construction of Digester 3.
18. Concrete mix design including strength at 3-day, 8-day, and 28-day ages (include 56-day strength for Primary Secant Piles). Trial mix test results shall indicate slump immediately after mixing.
19. Manufactures data for automated pile monitoring and recording equipment and example report. Provide calibration data and manufacture data for each component of the monitoring system, including digital display unit, depth sensor, magnetic flow meter, field printer, grout pressure sensor, and torque pressure sensor.
20. Methods for conducting the verticality measurements.
21. Pile construction data log.
22. Contingency and emergency plans and procedures, such as: removal of obstructions, remedial repairs.

1.06 GROUNDWATER CONTROL WORK PLAN

A. Develop a work plan to address methods to be used to monitor and control bottom stability of the borings.

PART 2 PRODUCTS

2.01 PERFORMANCE AND DESIGN CRITERIA

A. Subsurface Conditions: Refer to Geotechnical Data Report (GDR).

B. Secant Piles:

1. Construct the secant piles to the following tolerances and requirements:
   a. Center of Pile: Within plus or minus 1 inch of the locations indicated on the Contractor's approved design Drawings and Secant Pile Plan.
   b. Top Elevation of Pile: Within plus or minus 4 inches of the layout provided on the Contractor's approved Secant Pile Plan submittal and no lower than elevation 158 feet.
   c. Pile Tip Elevation: At or below the elevation indicated on the Contractor's design Drawings.
   d. Verticality: Construct individual piles within a tolerance of 1:200, or 0.5 percent, from vertical at any level over the upper 55 feet of each pile. Verticality of the piles below a depth of 55 feet shall be within a tolerance of 1:100 or 1.0 percent from vertical.
   e. Pile Diameter: Plus 1-inch or minus 0 inch of the diameter indicated on the Contractor's approved design Drawings and submitted Secant Pile Plan.
   f. Partial Depth Secant Piles: Contractor shall determine required minimum depth to maintain shaft stability. Install secant piles to at least elevation 132 feet.
   g. Leakage: Completed secant piles shall be cleaned to bare concrete by pressure washing. After cleaning, the exposed secant pile wall shall be free of all flowing water. Seal all flowing leaks in the secant pile wall. Flowing leaks shall be defined as a leak from which the water moves under the effects of wind or gravity. Moist patches that are not flowing are acceptable.
   h. Shaft Dimension at Inside Face of Secant Piles: Minimum radius indicated on the Drawings.
   i. Number of Piles: Equal to or greater than the indicated on Contractor's approved design Drawings.
   j. Refer to Drawings for all locations of utilities that will require penetrations through the secant pile excavation support system.
   k. Responsible for the design coordination of pile excavation support system with all disciplines including mechanical and electrical penetrations, landscaping, adjacent new structures, drain lines, etc.

2.02 TEMPORARY CASING

A. Temporary Casing: Capable of being installed and removed without disturbing the surrounding soil or damaging the pile shaft or adjacent piles. The outside diameter of the casing shall not be less than the pile diameter.

2.03 REINFORCING STEEL

A. As required per the Contractor's secant pile design.

B. Splices in reinforcing steel, if applicable shall be as required by the Contractor's design.

2.04 CONCRETE

A. Minimum concrete compressive strength as specified by the secant pile system designer in accordance with Article Secant Pile Shaft Information and Narrative Plan.

2.05 SLURRY

A. Nontoxic, easily degradable synthetic slurry or water slurry. Mineral slurries are not allowed.

1. Synthetic Slurry:
   a. Acceptable Manufacturers:
      1) Shore Pac GCV, CETCO.
      2) SlurryPro CDP, KB International.
      3) Super Mud, PDS Company.
      4) "Or-equal."
2. In conformance with the manufacturer's recommendations.
3. Mix Design:
   a. Appropriate for project requirements and conditions.
   b. Slurry manufacturer's onsite technician shall provide technical assistance and oversee the slurry preparation and use, recommend adjustments if necessary, and confirm the adequacy of the slurry for the site specific conditions.
4. Water: Clean, potable, and free of impurities detrimental to slurry, and compatible with the slurry mix design.
5. Performance Criteria:
   a. Hydrostatic Head Produced: Sufficient to provide hole stability and to prevent water and soil inflow to the drill-hole.

b. Viscosity or Rheology: Sufficient to seal weak and open soil formations.
c. Stability and Flow: Ensure that the slurry will remain stable and fluid during excavation and until concreting is completed, and flows without gelling under displacement by concrete.
d. Sand Content: Maximum of 0.5 percent by volume measured two feet from the bottom of the pile, just prior to concreting, in accordance with API 13B-1.
e. Other Slurry Properties or Additives: As deemed appropriate or necessary to provide hole stability.

6. Water: Water without site soils or slurry additive may be used to control bottom heave within secant pile excavation when casing is used for the entire length of the boring. Use of water without full length casing may only be used with the approval of the Project Representative.

PART 3 EXECUTION

3.01 GENERAL

A. A preconstruction conference for the secant pile excavation support system shall be held at least 5 days prior to beginning any pile construction to discuss construction procedures, personnel, equipment, and other aspects of the construction. This conference will not be held until the requisite submittals have been reviewed and been approved or accepted. The Contractor's superintendent, slurry manufacturer's onsite technician, and drilling Contractor's project manager and supervisor(s) shall attend this conference.

A. The slurry manufacturer's onsite technician shall be onsite as necessary to provide technical assistance and oversee the slurry preparation and use, recommend adjustments if necessary, and confirm the adequacy of the slurry for the site specific conditions. Both natural and synthetic slurry shall be disposed of offsite in accordance with local, state, and federal requirements.

B. Preparation:

1. Construct guide walls, level construction pad, and layout the secant piles as indicated on the Drawings and tolerances indicated herein.
2. Proper guide walls shall be constructed to help achieve the necessary position and vertical alignment of the secant piles within the required tolerances.
3. Guide walls shall be fully constructed prior to construction of secant piles.

C. Conduct work so as not to damage facilities or improvements that are to remain in place. Employ construction methods that prevent the spillage of excavated materials, drilling slurry, or concrete offsite onto streets, sidewalks, or other facilities.

3.02 DEMONSTRATION TESTING

A. Demonstration testing shall be conducted on three overlapping piles that are part of the secant pile wall.

B. Provide pile drilling and construction monitoring and recording measurements and analysis on the demonstration piles.

C. The Contractor will make a determination on the acceptability of the demonstration piles, based on the construction reports and construction monitoring test results and analyses.

D. For each demonstration pile, pile integrity testing shall be performed in accordance with ASCE D5882 by the approved Pile Integrity Testing consultant.

1. The integrity testing shall not be performed until the concrete has cured for a minimum of 7 days, unless otherwise approved by the Engineer.

E. For each demonstration pile perform the following testing:

1. Slurry, if used to maintain hole stability:
   a. Test results shall be within the particular manufacturer's acceptable range. Provide testing for:
      1) Density.
      2) Viscosity.
      3) pH.
      4) Sand content testing prior to placing concrete.
2. Concrete used for secant piles. Test concrete in each demonstration pile for:
   a. Unit weight and air content in accordance with ASTM C138.
   b. Slump in accordance with ASTM C143.
   c. Temperature in accordance with ASTM C1064.
   d. Strength testing of 6-inch by 12-inch cylinders. Prepare and cure a minimum of eight 6-inch by 12-inch cylinders for each of the demonstration piles in accordance with ASTM C31. Complete strength testing following ASTM C39. Two cylinders shall be tested at 3 days, two at 7 days, and two at 28 days with

two cylinders provided for reserve testing at cure times determined by the Engineer.

F. For each demonstration pile demonstrate the following procedures are completed in accordance with specification requirements:

1. Secant pile drilling and verticality control.
2. Concrete tremie placement.
3. Placement of reinforcing steel, if required by the Contractor's design.

G. If the adequacy to demonstrate of the proposed means and methods fails, or subsequently, materially changes the means and methods, additional demonstration testing as described herein will be required.

3.03 BORINGS FOR SECANT PILES

A. Install temporary casing as necessary to maintain the hole until concrete is placed. Casing shall be installed by either rotating or oscillating the casing. Installing the casing by vibratory means will not be allowed. Sufficient quantity of temporary casing shall be onsite at all times to maintain productivity.

B. Excavate in a manner such that the soil outside the pile diameter is not adversely affected and without excavating below the bottom of temporary casing. Use pile boring methods that will minimize over-excavation and loosening and caving of material outside the pile diameter. Anticipate that obstructions may be encountered and be prepared to implement appropriate procedures and equipment for their removal. Advise Project Representative immediately upon encountering obstructions. Fragments of any obstructions encountered shall be retained and provided to the Project Representative.

C. Perform borings continuously from ground surface to the required depth. If the pile shaft excavation cannot be completed in a single continuous operation, the pile shaft shall be backfilled to a minimum depth of 5 feet above the bottom of the casing and drilling slurry shall be maintained at such an elevation as necessary to prevent caving and bottom-of-hole instability. Similarly, do not leave a completed drilled shaft excavation open overnight. Either complete the shaft by placing concrete or temporarily complete as described.

D. Provide suitable equipment for checking plumb, alignment and dimensions of each pile hole excavation. Plumb, alignment, and dimensions shall be checked frequently, but at not less than at 15-foot intervals.

E. Maintain excavated soil within cased pile hole or fill each pile hole with slurry or water as necessary to maintain a stable hole. The process of advancing the borehole and the temporary casing shall be such that the soil is not drawn into the bore from outside the area of the pile and cavities are not created outside the temporary casing.

1. For drill systems where soil is incrementally removed from the cased pile hole, add water or slurry to the hole as necessary to prevent base heave or caving. Maintain a minimum excess pressure head of 10 feet at the base of the pile hole.
2. For cased auger or dual-rotary drill systems maintain base stability using continuous flight hollow shaft auger and creating a head of cement grout at least 10 feet above the point of injection as the auger is withdrawn through the bottom 30 feet of the pile. A head of cement grout shall be maintained at all times during the pumping and extraction process so that the grout has a displacing action removing any loose material.

F. Slurry:

1. Slurry, where used, shall be mixed, thoroughly hydrated, and tested for conformance with the design material properties before being placed in the drill hole.
2. The date, time, name of person sampling and testing and results shall be recorded and provided to the Project Representative.
3. Samples of slurry from the mid height and within 2 feet of the bottom of the drill hole shall be taken and tested at least once every 4 hours to verify the control of the slurry properties.
4. Sampling and testing shall be taken at least every 2 hours if the slurry is not re-circulated in the drill hole or if the previous sample did not have consistent design properties.
5. All slurry shall be re-circulated or agitated with the drilling equipment when tests show that the samples do not have consistent specified properties.
6. Slurry samples shall be taken and tested prior to final cleaning of the bottom of the hole and again prior to placing concrete.
7. Cleaning of the bottom of the hole and placement of concrete shall not start until tests show that samples taken at mid-height and within 2 feet of the bottom of the hole have consistent specified properties.
8. Clean, re-circulate, de-sand, or replace the slurry to maintain the required slurry properties.

G. Perform borings near utilities and duct banks that are to remain in place without causing damage to, or movement of, these facilities, including damage to completed piles.

H. Dispose of all excavated materials in accordance with applicable permits and regulatory requirements.

I. Do not advance adjacent primary pile borings within 24 hours of each other.

J. Do not advance secondary pile borings if adjacent primary piles contain unset concrete and concrete in adjacent primary piles has not been in place a minimum of 24 hours.

3.04 SECANT PILE INSTALLATION

A. Utilize temporary shoring and maintain slurry or water in the pile hole or utilize continuous flight augers with combination of soil and head of cement grout as necessary to prevent heaving and bottom-of-hole instability.

B. In the event that the results of the pile monitoring and associated measurements indicate the potential that the secant pile installation is out of compliance with the requirements for pile diameter, cross sectional shape, location or verticality, verbally communicate the potential to the Project Representative prior to placing reinforcing and/or concrete in the hole. The Project Representative may direct the Contractor to fill the hole with Controlled Density Fill to allow it to be redrilled in accordance with the specified tolerances.

C. Prior to placing reinforcing and/or concrete in the pile hole, clean the bottom of the hole of all loose material. No more than 6 inches of loose or disturbed material shall remain. Reinforcing shall be braced/supported such that it is properly situated and aligned within the pile (horizontally and vertically) and maintained during concrete placement.

D. Provide minimum of 2 inches of concrete cover over reinforcing steel.

E. Place concrete as soon as possible after completion of pile hole drilling, inspection of the hole, and placement of the reinforcing. Holes shall not be left open longer than 4 hours after drilling is completed at any stage of excavation. If for some reason this cannot be accomplished in certain instances, comply with the requirements of this section.

F. Place concrete by tremie method, in such a manner that the concrete displaces the slurry or excavated soil progressing from the bottom and rising uniformly level to the required top elevation. Concrete placement shall continue in one operation to the top of the pile hole and the elapsed time from the beginning of concrete placement in the pile hole to the completion of the placement shall not exceed 2 hours. Admixtures in the concrete mix shall be adjusted for the conditions encountered on the Job so that concrete remains in a workable plastic state throughout the 2-hour placement. Before concrete placement, test remains in a plastic state throughout the 2-hour placement. Before concrete placement, presubmit test results of both a trial mix and a slump loss test using methods to demonstrate the concrete meets the 2-hour requirement. The tests shall be conducted using concrete and ambient temperatures appropriate for site conditions. At the discretion of the Project Representative, a placement time in excess of 2 hours may be granted if the Contractor has previously requested an extended period of placement by documented procedures that can be used to maintain concrete in a workable state and can demonstrate that the concrete has remained workable for the specific secant pile where the extended placement period is requested.

G. The discharge end of the tremie pipe shall include a device to seal out water while the tube is first filled with concrete. The tremie shall be initially positioned at the bottom of the hole prior to placing concrete. Throughout the concrete placement operation, the discharge end of the tube shall remain submerged in the concrete at least 5 feet and always contain enough concrete to prevent water from entering.

H. If concrete placement is halted for any reason in a manner that could lead to defective concrete, the top surface of the tremie concrete shall be cut back to sound concrete and cleaned of all laitance and weak concrete. The remainder of the pile shall either be cast by tremie or in the dry. Where concrete is placed in the dry, the concrete shall be placed by tremie and the free fall of the concrete from the bottom of the tube shall not exceed 1.5 times the diameter of the pile. Temporary casing shall be extracted while the concrete within remains sufficiently workable to ensure that the concrete is not lifted. When the casing is withdrawn as concreting proceeds, a sufficient head of concrete shall be maintained to prevent the entry of groundwater that may cause reduction of cross-section of the pile.

3.05 SECANT PILE INSPECTION

A. Perform the pile installation monitoring continuously during pile drilling, tool extraction, and backfilling. The monitoring shall assure a minimum grout volume is pumped per unit depth increment.

B. Immediately inform the Project Representative of over-excavation, obstructions, or boring that is out of tolerance.

C. Use appropriate inspection devices before tremie concreting, to demonstrate that the pile hole bottom has been properly cleaned and excavated to the specified diameter, depth, verticality, and that the requisite overlap of piles will be attained.

D. Check concrete properties as required prior to placing. Closely monitor concrete placement and chart actual volume of concrete placed versus theoretical volume required.

E. Maintain pile construction log.

3.06 PILE MONITORING AND ANALYSIS

A. For all piles provide continuous monitoring during drilling, tool extraction, and backfilling of each pile. Monitor for:

1. Pile alignment.
2. Pile profile.
3. Extraction rate with pumped grout volume.
4. Concrete grout pressure.

B. Record preliminary results and findings of monitoring for each secant pile installed. Submit draft records within 4 hours after testing for the demonstration piles and within 24 hours after testing for production piles. Submit the final results, analyses and interpretations in accordance with ASTM D5882 and in reporting format. Submit test results within 3 days after testing. A final compilation report containing all of the secant pile installation records shall be prepared, stamped, dated, and signed by the testing firm’s or secant pile installation Contractor’s Professional Engineer. The report should document the secant pile construction activities, provide figures showing the layout and identification number of the secant piles, summarize the installation and monitoring activities performed, summarize nonconforming piles and methods used to correct or replace nonconforming piles.

C. Should the test results indicate that the secant pile is out of tolerance, or the test results appear suspect by either the testing firm's Professional Engineer or Project Representative, immediate notify the Project Representative. Retesting may be directed by the Project Representative.

3.07 SPOIL HANDLING AND DISPOSAL

A. Excess materials, waste and spoil shall be removed by the Contractor from the construction area and disposed of offsite in according to local code.

B. Continuously remove drilled spoil during shaft placement.

3.08 CORRECTION OF DEFECTIVE PILES/REMEDIAL REPAIRS

A. For those drilled pile shafts determined to be defective, the drilled hole shall be filled with Controlled Density Fill in order to permit the secant pile to be redrilled.

B. For those piles determined to be defective, submit a remedial action plan for review.

C. Remedial action plans shall demonstrate the suitability for the intended replacement of the out of tolerance pile. Remedial work shall not begin until the information submitted has been reviewed and the remedial action plan accepted. Allow 3 days for the Project Representative's review.

D. Remedial repairs and subsequent verification testing.

3.09 RECORD DRAWINGS

A. Maintain as-built records of the Work in accordance with the guidance provided in the ADSC Drill Shaft Inspector's Manual, including:

1. Pile identification.
2. Excavation depth and elevations of top and bottom of finished piles.
3. Summary of dates and times of construction of all pile borings, excavation, reinforcing and concrete placement.
4. Summary description of soils encountered on all pile borings, obstructions, and problems with excavation or concrete placement, if any.
5. Deviation of all piles from vertical, if any.

3.10 SHAFT EXCAVATION

A. Following completion of the secant pile wall excavate the interior of the shafts in accordance with Section 02315, Excavation.

B. Excavation shall not commence until the concrete in all of the piles has reached the minimum specified design strength.

C. Maintain the depth of excavation within 6 feet of level across the shaft during excavation.

D. Remove any protrusions or bulges interfering with construction or backfill of the Digester. Properly repair or grout any cavity that interferes with the installation of subsequent materials, or construction, or compromises the integrity of the wall (strength, leakage).

E. Repair leaks in the secant piles so that the leakage does not result in loss of ground outside the secant pile shoring system. Stop leakage using proven methods appropriate for the situation. Such repairs and repair materials will be subject to review by the Project Representative.

3.11 FINISHING

A. Clean the interior wall face to remove soil and loose concrete.

B. Repair all leaks such that the completed secant piles and excavated shaft to prevent the loss of ground outside of the shoring system.

C. Remove the top of the secant piles after construction of Digester 3 and placement of backfill around the digester as noted on the Drawings.

3.12 GEOTECHNICAL INSTRUMENTATION MONITORING

A. Install geotechnical instrumentation and monitor in accordance with Section 02205, Instrumentation and Monitoring.

3.13 FIELD QUALITY CONTROL

A. Control Testing of Synthetic Slurry: If synthetic slurry is utilized, use suitable means and methods to test and properly control quality of synthetic slurry.

B. Test Equipment and Methods: Provide test equipment and methods that conform to the requirements of API 13B-1.

C. As a minimum, take samples and perform tests specified below in accordance with referenced standards to verify that properties of slurry inside pile holes are within the specified limits during drilling, including sand content, prior to final cleaning and just prior to placing concrete. Comply with slurry manufacturer's technical representative's recommendations or requirements. Test results shall be within the particular manufacturer's acceptable range. Sand content prior to placing concrete shall be as specified in this section.

1. Density.
2. Viscosity.
3. pH.
4. Sand content.

D. Concrete used for secant piles for:

1. Unit weight and air content in accordance with ASTM C138.
2. Slump in accordance with ASTM C143.
3. Temperature in accordance with ASTM C1064.
4. The concrete mix shall be sampled using 6-inch by 12-inch cylinders. One set of concrete cylinders shall be collected for each day during which secant piles are constructed and six cylinder samples shall be collected for each 50 cubic yards of concrete placed. Cylinders shall be cured and tested in accordance with ASTM C31.
5. Strength Testing:
   a. During the progress of the Job standard compression testing shall be completed in accordance with ASTM C39 by the approved material testing laboratory.
   b. From each set of six cylinders, two shall be tested at 3 days, two at 7 days, and two at 28 days, unless specified strength has already been obtained.
6. Other testing and methods in accordance with Section 03300, Cast-in-Place Concrete.

E. Inspect concrete used in secant piles to the requirements stated herein.

3.14 CONSTRUCTION IN VICINITY

A. Do not excavate or drive piling outside of the secant pile wall which will expose the exterior face of the secant piles prior to the secant pile concrete reaching design strength.

3.15 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. TEC Geotechnical Data Report.[ADD. 1]

END OF SECTION

EXHIBIT A

Geotechnical Data Report

Version: Final

Clean Water Services
Tigard, Oregon

Durham WRRF Phase 6B Digester Preliminary Design
Project No. D3704504
CWS Project No 7203
April 29, 2024

Geotechnical Data Report

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Acronyms and Abbreviations

ASTM	ASTM International
bgs	below ground surface
bpf	blows per foot
CPT	cone penetration test
CRBG	Columbia River Basalt Group
CWS	Clean Water Services
DC1	Digester Complex 1
DC2	Digester Complex 2
GDR	Geotechnical Data Report
GPS	Global Positioning System
OAR	Oregon Administrative Rule
SPT	Standard Penetration Test
VWP	vibrating wire piezometer
WRRF	Water Resource Recovery Facility

1. Introduction

1.1 General

Clean Water Services (CWS) has retained Jacobs to perform subsurface exploration as well as design and construction support services associated with the preliminary design for Digester Complex 2 (DC2) at the Durham Water Resource Recovery Facility (WRRF), which is located at 16580 SW 85th Avenue in Tigard, Oregon. Figure 1 shows the project location.

Authorization for the scope of work associated with the project is provided by the Professional Services Contract between CWS and Jacobs, effective May 29, 2023. Task 2.2 of the project scope of work requires the development of this Geotechnical Data Report (GDR) summarizing the geotechnical field explorations.

1.2 Project Description

The 2019 East Basin Master Plan (Carollo et al. 2021) identified the need for a third digester at the Durham WRRF by 2027 to alleviate capacity deficits with respect to maintaining a 15-day solids retention time and 0.17 pound of indigenous volatile solids per cubic foot per day. Currently, the Durham WRRF operates two mesophilic anerobic digesters at DC2, with redundancy provided by two digesters at Digester Complex 1 (DC1) when one digester is out of service at DC2. The DC2 digesters are operated in parallel with an effective digestion volume of 1.3 million gallons each. DC2 co-digests thickened primary sludge and twice-thickened waste activated sludge, as well as fats, oils, and grease. The DC1 digesters have an effective digestion volume of 0.707 million gallon each. They typically remain out of service, but if used are fed sequentially.

1.3 Objectives and Scope of Work

The purpose of this GDR is to present findings of the geotechnical explorations at the proposed two locations for the new digester, along with the results of laboratory tests conducted on soil samples recovered during the explorations. The scope of work for the geotechnical program consists of the following:

- Review available geologic information
- Review data from previous geotechnical explorations
- Conduct a geotechnical field investigation at the proposed locations for the new digester that consists of geotechnical borings and cone penetration test (CPT) soundings
- Install and collect groundwater data from a standpipe piezometer and a vibrating wire piezometer (VWP)
- Develop and perform a laboratory testing program for physical analysis of selected samples collected from the geotechnical borings
- Characterize and summarize the general subsurface stratigraphy at the proposed locations for the new digester
- Prepare this GDR to summarize the results of the field investigations and laboratory testing program. Include supporting materials (Appendixes A through F) to supplement the report discussion

2. Exploration and Testing

This section summarizes the field exploration program, laboratory testing program, and results of previous explorations completed at the proposed locations for the new digester.

2.1 Current Field Exploration and Laboratory Testing Program

The geotechnical field exploration program completed at the proposed locations for the new digester consisted of advancing two CPT soundings on September 14, 2023, and two geotechnical borings advanced between September 21 and 24, 2023. The field explorations were completed in the presence of a Jacobs engineer who directed the drilling operations, collected samples, and provided continuous observation and logging of each of the boreholes. Procedures used in these explorations are described in Sections 2.1.1 through 2.13.

Locations of geotechnical explorations were read with a handheld global positioning system (GPS) device (Garmin 62S) and confirmed with GPS readings received from the client on February 12, 2024. Horizontal accuracy of the GPS device is approximately 10 to 15 feet. Vertical elevation for the borings was determined from topographic and bathymetric surveys completed for this project based on the GPS coordinates. The locations of the explorations are shown in Figure 2.

2.1.1 Geotechnical Borings

The geotechnical exploration program for this project consisted of completion of two geotechnical borings, designated B-01 and B-02. Boring locations, coordinates, final completion depths, and surveyed ground surface elevations at the boring locations are summarized in Table 2-1.

Table 2-1. Summary of Borings

Boring	Northing (Int. feet)[a]	Easting (Int. feet)[a]	Approximate Location	Completion Depth (feet bgs)	Ground Surface Elevation (feet)[b]
B-01	640049.38	7620132.03	SW 85th Ave Tigard, OR, N of DC2 Flare	101.5	163.79
B-02	639881.52	7620148.01	SW 85th Ave Tigard, OR, S of DC 2 Flare	76.5	158.95

Notes:
a. Coordinate System: Oregon State Plane Coordinates – North Zone. Horizontal datum: NAD83, National adjustment of 2001.
b. Vertical datum: NGVD29.
Abbreviations:
bgs = below ground surface
Int. = international
NAD83 = North American Datum of 1983
NGVD29 = National Geodetic Vertical Datum of 1929

The geotechnical borings were drilled by Western States Soil Conservation, Inc., of Hubbard, Oregon. The borings were advanced using a track mounted CME-75 drill rig. The borings were drilled using the mud-rotary technique.

During drilling, soil sampling was performed using 18-inch-long split spoon samplers with a 2-inch outside diameter, 1.38-inch inner diameter (constant, i.e., no room for liners). Split-spoon samplers were driven using an automatic trip hammer weighing 140 pounds and falling 30 inches, in general accordance with standard procedures outlined in ASTM International (ASTM) D1586, "Standard Test Method for

Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils." This test is used to characterize the consistency of fine-grained soil or the relative density of coarse-grained soil by measuring penetration resistance expressed as blow counts, or N-value. The number of blows required to advance the standard split-spoon sampler 6 inches into the ground with a 140-pound hammer falling 30 inches is recorded. The sampler is driven in three 6-inch increments for a total of 18 inches, and the blow count is recorded for each 6-inch increment. The sum of the blow counts for the second and third increments is referred to as the SPT blow count or N-value in blows per foot (bpf). Low N-values indicate soft or loose soil; high N-values are evidence of hard or dense materials. SPT refusal is defined as the point where 50 blows from the standard 140-pound hammer falling 30 inches results in less than 6 inches of penetration of the sampler. After the sampler is driven and the blow counts are recorded, the sampler is withdrawn from the borehole to recover a disturbed soil sample.

During SPT sampling, the energy transferred from the falling hammer to the SPT sampler varies depending on various factors, including hammer type, and driving system. The calibrated hammer energy ratios for each drill rig used for the exploration were provided by Western States Soil Conservation Inc. and are presented in Table 2-2. The energy transfer ratio for each rig was measured in November 2023.

Table 2-2. Calibrated Hammer Energy

Boring	Drill Rig	Energy Transfer Ratio[a] (%)
B-01	CME-75 Track-Mounted Rig #4 and #5[b]	76.8, 84.1
B-02	CME-75 Track-Mounted #5	84.1

Notes:
a. Provided by Western States Soil Conservation Inc.
b. Rig #4 was replaced with Rig #5 at the depth of 90 feet, owing to Rig #4 malfunction.

In select depths and locations, relatively undisturbed samples of fine-grained soils were collected in accordance with standard procedures outlined in ASTM D1587, "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes." A soil sample in this test is recovered by pushing a 30-inch-long steel Shelby tube with a 3-inch outer diameter and 0.065-inch wall thickness into the bottom of the borehole. The tube, together with the encased soil, is then removed from the borehole and sealed before transporting. The sealed sample can be extruded from the tube and logged or used for other laboratory tests.

Soil classification systems attempt to group soils that have similar engineering behavior (based on index tests). Several classification systems have been developed, usually for a specific application. The system most generally accepted for a wide range of engineering applications is the Unified Soil Classification System. The use of this method of classification provides a basis for the comparison of soils from widespread geographic areas. Soil samples recovered from the soil borings were examined and visually classified in accordance with ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)," which follows the Unified Soil Classification System. Upon receipt of laboratory test data, soil descriptions and classifications were updated in accordance with ASTM D2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)."

Upon borehole completion, the borehole not designated for conversion to piezometers was abandoned in accordance with Oregon Water Resources Department regulations (Oregon Administrative Rule [OAR] 690-240) to prevent vertical water migration.

Sampling intervals, stratigraphy, groundwater occurrence, and descriptions and classifications of soil samples were recorded on the boring logs presented in Appendix A. Photographs of the field explorations are presented in Appendix B.

2.1.2 Piezometer Installations

The geotechnical exploration program included the installation of a standpipe piezometer within boring B-01 to facilitate periodic observation of the depth to groundwater. The piezometer was installed by Western States Soil Conservation Inc. per Oregon Water Resources Department regulations defined by OAR 690-240 and Oregon Revised Statutes 537.880 through 537.895. The standpipe piezometers consist of a 2-inch-diameter polyvinyl chloride casing and machine-slotted screen. Sand was placed in the annular space from 1.5 feet below the bottom of the screen to 2.8 feet above the top of the screen. A bentonite seal was placed above the sand and up to the concrete-sealed monument. Piezometers were protected at the surface with a traffic-rated flush-mount monument set in concrete.

A Geokon model number 4500S-700KPA VWP was installed within the standpipe piezometer at boring B-01 to monitor daily groundwater fluctuations. The installed VWP installed is unvented and has a maximum pressure capacity of 700 kiloPascals (approximately 234 feet of water). Data are collected from the VWP four times every day and downloaded every few months. After collection, data are stored on waterproof Geokon 8943-01C-WP series dataloggers. Prior to installation, the initial zero reading for the VWP sensor was recorded per manufacturer recommendations. A VWP sensor was installed near the bottom of the screened interval. A summary of the installed piezometer and screen interval is presented in Table 2-3.

Table 2-3. Piezometer Installations

Boring	Completion Depth (feet bgs)	Screen Interval (feet bgs)	VWP Sensor Level (feet bgs)	VWP Serial No.	VWP Datalogger Serial No.
B-01	101.5	30–40	36.85	2267478	2311480

Abbreviations:
bgs = below ground surface
VWP = vibrating wire piezometer

2.1.3 Cone Penetration Testing

The geotechnical exploration program consisted of two CPT soundings, designated C-01 and C-02, at the proposed location for the new digester (Figure 2). The CPTs were conducted by Oregon Geotechnical Exploration Inc. of Keizer, Oregon. The electro-piezocone (VTK HT 10-square-centimeter 10-ton digital cone) was manufactured by Vertek CPT and was advanced in the subsurface soil at a rate of approximately 0.8 inch (2.0 centimeters) per second by a 25-ton truck-mounted platform. The cone had a cross end area of 1.55 square inches (10 square centimeters), and a cone area ratio of 0.8. The CPT soundings were advanced in general accordance with standard procedures outlined in ASTM D5778, "Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils." The CPT soundings were planned to be advanced to refusal (when the equipment is unable to advance the CPT further) or a maximum depth of 100 and 80 feet for C-01 and C-02, respectively. Both CPT soundings were terminated due to refusal. Refusal for CPT testing may involve several factors, such as tip resistance exceeding 500 tons per square foot or sleeve pressure exceeding 10 tons per square foot.

Downhole seismic shear-wave velocity measurements were conducted for CPT sounding C-01. Seismic shear-wave velocity measurements were collected for each 6.5-foot (2-meter) interval as the electro-piezocone was advanced.

A pore pressure dissipation test was conducted in each sounding to measure the dissipation rate of excess pore pressure generated by advancing the cone penetrometer. To perform this test, the piezocone was advanced into the subsoil at a standard rate. Pore pressures were measured immediately and at several time intervals thereafter. The recorded data were used to plot pore pressure dissipation versus log-time.

CPTs were abandoned on completion in accordance with Oregon Water Resources Department regulations (OAR 690-240).

The CPT sounding locations and depths are summarized in Table 2-4. The locations of the CPT soundings are shown on Figure 2, and the CPT sounding logs and tabulated data are presented in Appendix C.

Table 2-4. Summary of Cone Penetration Tests

CPT Sounding	Northing (Int. feet) [a]	Easting (Int. feet)[a]	Depth (feet bgs)	Ground Surface Elevation (feet)[b]
C-01	640050.51	7620149.91	85.3	164.20
C-02	639871.65	7620243.93	80.4	159.79

Notes:
a . Coordinate System: Oregon State Plane Coordinates – North Zone. Horizontal datum: NAD83, National adjustment of 2001.
b. Vertical datum: NGVD29.
Abbreviations:
bgs = below ground surface
CPT = cone penetration test
Int. = international
NAD83 = North American Datum of 1983
NGVD29 = National Geodetic Vertical Datum of 1929

2.1.4 Laboratory Testing

A laboratory testing program was developed to provide classification and engineering properties of the soil samples obtained from the geotechnical borings. The soil laboratory testing was conducted by FEI Testing and Inspection Inc. of Corvallis, Oregon. Soil laboratory testing was performed using the following methods:

- ASTM D1140, Standard Test Methods for Determining the Amount of Material Finer Than 75-µm (No. 200 Sieve) in Soils by Washing
- ASTM D2166, Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
- ASTM D2216, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D2435, Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
- ASTM D2937, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
- ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Table 2-5 summarizes index laboratory testing results completed on representative soil samples collected during the geotechnical explorations. Table 2-6 and Table 2-7 summarize one-dimensional consolidation parameters and unconfined compressive strength obtained from testing completed on select soil samples collected from relatively undisturbed thin-walled Shelby tube samplers.

The complete laboratory test reports are included in Appendix D. Laboratory test results are also included in the “comments” section of the boring logs in Appendix A.

Table 2-5. Summary of Laboratory Test Results

Boring, Sample	Depth Interval (feet bgs)	Moisture Content (%)	Liquid Limit	Plasticity Index	Fines Content (%)	Sand Content (%)	Gravel Content (%)
B-01, SS-3	8.5–10	32.2	36.3	27.9	8.4	62.8	0.0
B-01, SS-5	15–16.5	27.0	NV	NP	NP	27.0	0.0
B-01, SS-7	25–26.5	23.7	NT	NT	NT	31.5	0.0
B-01, SS-10-A	40–41	22.1	NV	NP	NP	24.2	0.0
B-01, ST-13	46.5–48.5	33.7	41.2	15.0	26.2	65.3	0.8
B-01, SS-15	55–56.5	38.2	48.8	25.6	23.2	NT	NT
B-01, SS-18-A	65–66	38.9	43.9	26.7	17.2	NT	NT
B-01, SS-21	80–81.5	35.5	57.2	23.8	33.4	63.9	0.0
B-01, SS-25	100–101.5	38.0	50.1	26.4	23.7	NT	NT
B-01, SS-3	8.5–10	32.2	36.3	27.9	8.4	62.8	0.0
B-02, SS-3	10–11.5	27.8	29.6	21.3	8.3	45.3	0.0
B-02, ST-5	16.5–18.5	59.8	77.2	52.6	24.6	48.2	0.0
B-02, SS-6	20–21.4	26.4	25.8	20.9	4.9	NT	NT
B-02, SS-8	25–26.5	34.7	30.8	26.4	4.4	54.7	0.0
B-02, SS-11	40–41.5	21.5	NV	NP	NP	41.4	0.0
B-02, ST-13	46.5–48.8	25.1	NV	NP	NP	21.4	5.1
B-02, SS-14-B	50.25–51.5	29.9	30.7	21.4	9.3	74.3	0.4
B-02, SS-17	65–66.5	30.0	60.1	18.0	42.1	NT	NT
B-02, SS-19	75–76.5	38.5	NT	NT	NT	36.9	0.9

Abbreviations:
bgs = below ground surface
NP = non-plastic
NT = not tested
NV = no value

Table 2-6. Summary of One-Dimensional Consolidation Test Results

Boring, Sample	Sample Depth (feet bgs)	Preconsolidation Pressure (ksf)	Compression Index (Cc)	Recompression Index (Cr)
B-02, ST-5	16.5-18.5	3.0	0.18	0.01

Abbreviations:
bgs = below ground surface
ksf = kips per square foot

Table 2-7. Summary of Unconfined Compression Test Results

Boring, Sample	Sample Depth (feet bgs)	Moisture Content (%)	Liquid Limit	Plasticity Index	Moist Bulk Density (pcf)	Unconfined Compressive Strength (psf)	Undrained Shear Strength (psf)
B-01, ST-13	46.5–48.5	30.5	41.2	26.2	122.3	777.6	388.8
B-02, ST-5	16.5–18.5	31.3	77.2	24.6	116.5	950.4	475.2

Abbreviations:
bgs = below ground surface
pcf = pounds per cubic foot
psf = pounds per square foot

2.2 Previous Investigations

Clean Water Services provided Jacobs with reports of previous geotechnical explorations that were performed at the Durham WRRF site. These reports were reviewed to determine the locations of historical borings in the vicinity of the project site and to gather information on the historical groundwater levels in addition to the levels shown by the newly installed piezometer within boring B-01.

Table 2-8 summarizes the previously completed geotechnical borings near the project site. Subsurface investigation data (boring logs with laboratory test data) relevant to this project are provided in Appendix E, and summaries of the previously completed investigations are presented in the following paragraphs. Subsurface information from these previously completed geotechnical explorations was used to supplement information obtained from the current field exploration.

Table 2-8. Summary of Previously Completed Borings Near the Digesters

Exploration Number	Location	Ground Surface Elevation (feet)	Depth (feet bgs)	Water Level (feet bgs)
2011 Durham Advanced Wastewater Treatment Facility Cogeneration and Brown Grease Receiving Facilities Project				
B-1-11	Cogeneration facility	175.6	55.0	NR
B-2-11	Brown grease facility	169.6	41.5	NR
2010 Clean Water Services Durham Wastewater Treatment Plant Phase 5B1 Project				
B-1-10	6 feet northwest of existing headworks building	180	31.5	NR
2003 Durham Facility Phase 4 Expansion Project				
BH-9	Influent pump station	152	111.5	45
BH-10	Influent pump station	125	81.5	20
BH-11	Influent pump station	117	61.5	8
BH-12	Influent pump station	114	51.5	13
BH-13	Influent pump station	126	81.5	NI
BH-14	Influent pump station	117	61.5	13
BH-15	Influent pump station	117	54.5	NI
BH-16	Near proposed digester	162	21.5	NR
1998 Advanced Wastewater Treatment Plant Expansion Phases 3, 4, and 5 Pre-Design				
BH-1	Influent pump station	138	86.5	20
BH-3	300 feet southeast of influent pump station	117	71.5	8
BH-4	Influent pump station	129	51.5	16
BH-8	Existing diesters	158	81.5	NR

Abbreviations:
bgs = below ground surface
NI = no information
NR = not recorded

2.2.1 2011 Durham Advanced Wastewater Treatment Facility Cogeneration and Brown Grease Receiving Facilities Project

In 2011, CH2M HILL conducted drilling activities (B-1-11, B-2-11) adjacent to the cogeneration facility. Despite the absence of piezometers for groundwater level monitoring during the 2011 field exploration, wet soil samples were observed at depths of 25 and 30 feet below ground surface (bgs) in B-1-11, as well as at 30 feet bgs in B-2-11 (CH2M Hill 2013). These wet conditions suggest the potential presence of perched groundwater. Subsurface investigation date (boring logs and laboratory test data) is provided in Appendix E.1.

2.2.2 2010 Clean Water Services Durham Wastewater Treatment Plant Phase 5B1 Project

In 2010, CH2M Hill advanced one soil boring (B-1-10) next to the headworks building. Groundwater was not recorded during the investigation (CH2M Hill 2010). The boring log is provided in Appendix E.2.

2.2.3 2003 Durham Facility Phase 4 Expansion Project

In 2003, Squier | Kleinfelder conducted drilling activities including 10 borings and four deep test pits. Depth of the borings ranged from 22 feet to 112 feet bgs and the depth of test pits ranged between 24 feet and 26 feet bgs. Groundwater piezometers were installed in all the borings except BH-16 and BH-18. Eight of the borings (BH-9 through BH-16) and four test pits (TP-1 through TP-4) were near the influent pump station. Based on the groundwater measurements and observations during the drilling, groundwater elevations appeared to range from approximately elevation 104 feet to elevation 118 feet. The exploration, which focused on the area around the Influent Pump Station and south of the proposed Cogeneration and Brown Grease Receiving Facilities, revealed a groundwater elevation of 156.7 feet at boring BH-18 on October 27, 2004. This groundwater level is identified as a perched groundwater zone, predominantly observed in the sandier sections of the interlayered silt and silty sand layer. Groundwater monitoring indicated that the elevation decreases (becomes deeper) to the south and increases (becomes shallower) to the north (Squire/Kleinfelder 2005). According to their assessment, the groundwater elevation in the vicinity of the Influent Pump Station is approximately 115 feet.

Soil corrosivity assessments were conducted at boreholes BH-17 and BH-18, located near the headworks building, as well as at BH-9, adjacent to the influent pumping station. These assessments involved analyzing the chemical content of corrosive elements, including chloride and sulfate, as well as measuring the pH and soil resistivity. Table 2-9 summarizes the corrosivity test results. Detailed information from the subsurface investigation, including boring logs and laboratory test data, can be found in Appendix E.3.

Table 2-9. Summary of Previously Completed Corrosivity Test Results

Boring, Sample	Depth (feet bgs)	Chloride (mg/kg)	Sulfate (mg/kg)	PH	Resistivity (ohm-cm)
BH-9, S-5	24	ND	ND	6.0	17,000
BH-17, S-1	5	ND	ND	5.3	11,000
BH-18, S-1	5	ND	109	5.4	5,500
BH-18, S-6	25	ND	ND	7.2	2,100

Source: Squier | Kleinfelder (2005)
Abbreviations:
bgs = below ground surface
mg/kg = milligrams per kilogram
ND = not detected
ohm-cm = ohm-centimeter

2.2.4 1998 Durham Advanced Wastewater Treatment Plant Expansion Phases 3, 4, and 5 Pre-Design

In 1998, Hart Crowser conducted a geotechnical exploration program consisting of seven borings and seven CPTs (Hart Crowser 1998). Four of the borings (BH-1, BH-3, BH-4, Bh-8) and five of the CPTs (PH-1, PH-3, PH-4, PH-6, PH-7) were in the vicinity of the influent pump station, which is adjacent to the location of the newly proposed digester. Groundwater observation wells were installed in five borings (BH-1, BH-2, BH-3, BH-4, and BH-7) upon completion of drilling. Based on these measurements, the water level appears to be at elevation 118, 109, and 113 feet in BH-1, BH-3, and BH-4, respectively. The report also notes that construction excavations showed the presence of perched groundwater at the project site. The subsurface investigation data (boring logs and laboratory test data) are provided in Appendix E.4.

2.2.5 Durham Advanced Wastewater Treatment Plant Chemical Expansion Project

Rittenhouse-Zeman & Associates, Inc. advanced nine borings (B-7, B-8, B-9, B-10, B-11, B-12, B-16, B-17, and IIB-1) near the headworks building and biofilter in 1991 (RZA 1991). Groundwater was only identified at a depth of 18.5 feet below the current grade in boring B-10. The majority of the borings exhibited perched water in the sand layers. Piezometers were installed in B-14 and B-15, with plans for one in B-5. However, B-5 turned out to be dry during drilling, so it was left open. Upon reevaluation several days later, the hole remained dry, leading to its backfilling without a piezometer. There is a possibility that existing underground utility trenches may have contributed to the drying up of certain areas on the site. The boring logs can be found in Appendix E.5.

2.2.6 Tualatin River Sewage Treatment Project

In 1972, Dames & Moore advanced two soil borings (Boring 10 and Boring 11) approximately 600 to 700 feet east of the headworks building. The findings from this investigation revealed that groundwater was not encountered in boring B-10, which was drilled to an elevation of 128 feet. On the other hand, groundwater was encountered at 36 feet bgs (at approximately elevation 126 feet) in B-11 (Dames & Moore 1972). Boring logs are provided in Appendix E.6.

3. Geology

This section describes the regional and mapped geology in the vicinity of the project site.

3.1 Regional Geology

The Durham WWRF is located within the Tualatin Basin of the Willamette Lowland geological province. This geological province is a structural and erosional lowland area bordered by the uplifted marine rocks of the Coast Range to the west and volcanic rocks of the Cascade Range to the east. Continental and marine strata interfinger beneath and adjacent to the Willamette Lowland. The Willamette Lowland extends from Eugene, Oregon, north to the Lewis River in southern Washington. In the northern two-thirds of the lowland, the marine sedimentary rocks and Cascade Range volcanic rocks are overlain by up to 1,000 feet of lava of the Columbia River Basalt Group (CRBG). Folding and faulting during and after incursion of the CRBG formed four major depositional basins: the Portland Basin, the Tualatin Basin, the central Willamette Valley, and the southern Willamette Valley. These basins, separated in most places by uplands capped by CRBG, have locally accumulated more than 1,600 feet of fluvial sediment derived from the Cascade and Coast ranges or transported into the region by the Columbia River (Gannett and Caldwell 1998).

The project alignment is in southeast Tualatin Valley, which runs northwest to southeast and is bordered by the Tualatin mountains to the north and east, the Chehalem mountains to the southwest, and the Coast Range to the west.

The Tualatin Valley is a bowl-shaped syncline underlain by Columbia River Basalt with a fluvial and lacustrine filling of Hillsboro Formation and flood deposit. The structural basement of the Tualatin Basin is composed of nearly 1,000 feet of middle Miocene (about 17 to 6 million years before the present time) weathered and unweathered lava flows with occasional interflow zones of breccia, ash, and baked soil horizons, collectively referred to as CRBG. During the late Miocene and Pliocene epochs (about 5 to 1.5 million years ago), complex folding and faulting of the CRBG produced the basin, including the surrounding uplands to the north, east, and south, as well as Cooper and Bull Mountains, which divide the basin into two subbasins, a larger northern subbasin north of Cooper and Bull Mountains, and a smaller southeastern subbasin.

Over the span of geologic time, nonmarine sedimentary deposits consisting of clay, silt, sand, and minor fine gravel have accumulated in the basins that formed on the CRBG. The fine-grained fluvial and lacustrine sediments derived from the local highlands surrounding the Tualatin Valley. These sediments of upper Miocene to Pleistocene age, which directly overlie the weathered surface of the CRBG, have been defined as the Hillsboro Formation (Wilson 1998). The thickness of the Hillsboro Formation varies from a feather edge at the basin margins to over 1,500 feet in the central part of the basin (under the city of Hillsboro).

During Pleistocene time, large-volume glacial-outburst floods originating from Lake Missoula in western Montana periodically flowed down the Columbia River drainage and inundated the Willamette Lowland. These catastrophic floods deposited up to 120 feet of flood deposits (averaging 60 to 90 feet thick) in the Tualatin Basin (Madin 1994, Gannett and Caldwell 1998). The Missoula flood deposits, also referred to as Willamette Silt, are dominated by silt composed primarily of quartz, feldspar, ferromagnesian minerals, and mica, with varying amounts of clay and fine sand (Gannett and Caldwell 1998). The flood sediment also contains glacial erratics ranging in size from pebbles to boulders as large as 10 feet in diameter (Gannett and Caldwell 1998, Ma et al. 2012). Except where the Missoula flood deposits have been eroded

or covered by younger alluvial sediments, they mantle all of the older sediments in the Tualatin Valley below an elevation of about 250 feet (Schlicker and Deacon 1967).

The youngest materials in the area are those deposited by the Tualatin River and its many tributary creeks and streams, which have eroded older sediments and redeposited them further downstream along their floodplains. These modern sedimentary deposits, or Holocene alluvium (less than 11,700 years old), are referred to as young alluvium, and mainly consist of silty clay, clayey silt, and fine sand, with local areas of peat and organic clay. The thickness of the Holocene alluvium varies with location and is difficult to determine because there is little distinction between the Holocene alluvium and the Missoula flood deposits from which the Holocene alluvium originated.

Along the project alignment, fill materials are locally present with variable thicknesses. These materials were generally placed as part of roadway projects or when sites were graded prior to development.

3.2 Mapped Surficial Geology

The project is near the southeastern edge of the Tualatin Basin. The mapped geology unit at the project site is fine Missoula flood deposits (Mff) but multiple surficial geologic units are mapped within 1 mile of the proposed digester by Ma et al. (2012) and Wells et al. (2020), and these deposits are shown on Figures 3 and 4, respectively. The mapped geologic units are:

- **Fine flood deposits (Mff)** comprise white or tan sand and silt, deposited in distinct layers ranging from a few inches to a few feet in thickness. Each layer corresponds to a single flood event, as documented by Waitt (1985), Benito and O'Connor (2003), and Waitt et al. (2009). These deposits extend across the entire Tualatin Valley, the majority of the northern Willamette Valley, and expansive areas of Portland.
- **Coarse flood deposits (Mfc)** are primarily composed of extensive, dark-grey gravel sheets that overlap and stretch from the mouth of the Columbia River Gorge at Troutdale to the Willamette River. The landscape vividly displays the origin of Mff and Mfc deposits, featuring massive gravel bars formed beneath the floodwaters. Scattered across the area are boulders, some as large as 10 feet in diameter, which were transported by the tremendous force of the floodwaters, often carried along with large chunks of glacial ice (Waitt 1985, Minervini et al. 2003). Additionally, significant bodies of coarse flood deposits can be found at Canby and Durham, where the floods deposited rocks scoured from the Willamette River narrows at Oregon City and from Oswego Lake.
- **Fine alluvium (Alf)**, composed of sand, silt, clay, and a small proportion of gravel, occupies the channels and floodplains of the Tualatin and Willamette Rivers. Due to the gentle slopes of both rivers, the predominant sediment they transport is fine material. The Willamette River features Ross Island, a substantial gravel deposit exceeding 130 feet in thickness, possibly remnants from the Missoula floods. All these deposits have formed after the conclusion of the Missoula floods and are, therefore, younger than 12,000 years. These loosely packed, water-saturated sediment deposits are highly susceptible to liquefaction during intense earthquake shaking.
- **Creek alluvium (Alck)** is a combination of sand, silt, clay, and gravel that has been deposited within the channels and on the floodplains of small streams. In regions affected by the Missoula floods, existing creeks underwent either scouring or burial in sediment. Following the conclusion of the floods, some of these creeks resumed their previous courses, while many were compelled to forge new channels. Creeks situated below the flood level have shaped their channels and floodplains over the 12,000 years since the floods concluded. Conversely, creeks positioned above the upper limit of the Missoula floods remained unscoured or buried, suggesting they may have been in their current locations for tens of thousands or even hundreds of thousands of years.

4. Interpreted Site Conditions

Results of field explorations, as well as information about the regional and local mapped geology described in Section 3, were used to evaluate surface and subsurface soil and groundwater conditions at the proposed locations for the new digester. Sections 4.1 and 4.2 summarize the interpretation of available site condition information.

4.1 Observed Subsurface Conditions

The subsurface soil profile described below is based on the geotechnical data collected during the subsurface exploration program and previous investigations conducted in the vicinity of the project area:

- **Silt, Silty Sand, Clayey Sand, Poorly Graded Gravel (ML, SM, SC, GP):** This unit represents fill material, which consists mostly of silt and silty sand. Poorly graded gravel with sand and clayey gravel were observed from the ground surface to depths of 2 feet and 2.5 feet bgs in B-01 and B-02, respectively. This layer was hand-augured to ensure the absence of irrigation lines. The gravel layer was medium dense with angular particles. In B-02, the hand auguring process faced difficulties due to the presence of coarse gravel and cobbles. Silt and silty sand were observed from 2.5 to 11.5 feet bgs in B-01. The silt was generally brown, moist, stiff, contains fine grained sand, and contains an estimated 60 percent fines (material passing the No. 200 sieve). The silty sand observed in B-01 was dark brown, wet, medium dense and contains fine grained sand. Clayey sand was encountered in B-02 from 5 to 6.5 feet bgs. The average uncorrected field SPT N-values for this layer range from 11 to 16 bpf with an average of 13 bpf.

- **Loose Sand (SP, SP-SM, SC-SM):** This unit consists of poorly graded sand, poorly graded silty sand, and clayey silty sand, predominantly identified in B-02 at depths ranging from 10 to 30 feet bgs. This unit was only encountered in B-01 between 15 and 20 feet bgs. The predominant soil type is clayey sand, which was generally dark gray, moist, and loose with fine sand. The uncorrected field SPT N-values ranged from 3 to 9 bpf with an average of 6 bpf.

- **Medium Dense Sand (SC, SP, SM, SC-SM, SP-SM):** Medium dense silty sand and clayey sand was encountered in both borings at depths ranging from 21 to 41 feet bgs in B-01 and 30 to 45 feet bgs in B-02. This layer was generally dark gray to dark brown with orange mottling, wet, medium dense with fine to coarse sand and a trace of gravel. The uncorrected field SPT N-values ranged from 12 to 31 bpf with an average of 23 bpf.

- **Firm Lean Clay with Sand, Sandy Silt (CL, ML):** This layer was only encountered in B-02 at depths from 25 to 26.5 feet bgs and 50.25 to 51.5 feet bgs. This layer was brown or gray, wet, firm, with fine to coarse sand and a trace of organic. The uncorrected field SPT N-value for this layer is 6 bpf.

- **Stiff to Very Stiff Clay, Silty Clay, Silt (CL, ML, CL-ML):** This unit consists of stiff to very stiff clay and silt with an average plasticity index of 22. This layer was predominantly encountered in boring B-01 from 41 to 65 feet bgs. In B-02, a 12-inch thick layer was identified between 45 and 46 feet bgs. This layer was generally brown with black and orange mottling, wet, stiff to very stiff, and low plastic with a trace of gravel. The uncorrected field SPT N-values ranged from 12 to 27 bpf with an average of 19 bpf.

- **Very Stiff High Plastic Clay and Silt (CH, MH):** This unit consists of highly plastic clay and silt with an average plasticity index of 33. This layer was encountered below 66 feet bgs in B-01 and below 55 feet bgs in B-02. This layer was mostly greenish blue color, wet, very stiff, and high plastic. The uncorrected field SPT N-values ranged from 12 to 31 bpf with an average of 22 bpf.

- **Organic Material (OH):** Organic material was only encountered in B-02 between 16.2 and 16.5 feet bgs. This layer was dark brown, wet, very loose and had high plasticity. The uncorrected field SPT N-value is 3 bpf.

Table 4-1 summarizes the average values of the laboratory testing conducted on the seven primary soil and rock units encountered in the geotechnical borings.

Table 4-1. Average Values of Laboratory Test Results

Soil Unit	Soil Layer	SPT N-Value	Moisture Content (%)	Liquid Limit	Plasticity Index	Fines Content (%)	Sand Content (%)	Gravel Content (%)
1	Silt, Silty Sand, Clayey Sand, Poorly Graded Gravel (ML, SM, SC, GP)	13	32.2	36	8	62.8	37.2	0.0
2	Loose sand (SP, SP-SM, SC-SM)	6	35.3	44	13	40.2	59.8	0.0
3	Medium dense sand (SC, SP, SM, SC-SM, SP-SM)	23	26.2	NV	NP	31.1	67.7	1.2
4	Firm Lean Clay with Sand, Sandy Silt (CL, ML)	4	32.3	31	7	64.5	35.3	0.2
5	Stiff to very stiff Clay, Silty Clay, Silt (CL, ML, CL-ML)	19	36.9	45	22	65.3	33.9	0.8
6	Very stiff high plastic clay and silt (CH, MH)	22	34.5	56	33	63.9	36.1	0.0
7	Organic (OH)	3	NT	NT	NT	NT	NT	NT

Abbreviations:
NP = non-plastic
NT = not tested
NV = no value
SPT = Standard Penetration Test

4.2 Groundwater Levels

The geotechnical borings completed as part of the Jacobs exploration program at the proposed locations for the new digester were primarily advanced using a mud rotary drilling method; the groundwater could not be clearly identified at the time of the explorations because the mud rotary drilling method circulates fluids through the borehole and obscures the presence of groundwater. A standpipe monitoring well with a VWP were installed in boring B-01, as described in Section 2.

Groundwater level data measurements have been recorded at boring B-01 VWP since October 2023. The groundwater levels were also recorded using a hand-held electronic water-level meter to verify the VWP data.

Raw VWP and temperature readings were collected every 6 hours and stored on a datalogger. The raw VWP data were converted to pressure values and corrected for temperature following manufacturer-provided calibration factors. The VWP model selected for this project is unvented, signifying that it responds to changes in atmospheric pressure. Therefore, groundwater data should be corrected for changes in atmospheric pressure; otherwise, the groundwater levels may be inaccurate. For example, a change in atmospheric barometric pressure of 29 to 30 inches of mercury that is not corrected may result in an approximate error of 1.1 feet in the measured groundwater level. Daily atmospheric barometric pressure data were obtained from the closest publicly available weather station, located at Tigard, Oregon

(via the Weather Underground website at https://www.wunderground.com/). The temperature-corrected VWP readings were also corrected for barometric pressure changes based on this data and manufacturer-provided calibration factors.

The historical groundwater data from existing geotechnical reports is summarized in Table 2-8. Table 4-2 presents the measured groundwater levels using the water-level meter at B-01. Groundwater level plots showing temperature-corrected VWP data, barometric pressure-corrected VWP data, precipitation depth, and water-level meter data are included in Appendix F. The groundwater levels recorded with the water-level meter confirmed the data collected from the VWP.

Table 4-2. Groundwater Level Measurements in Boring B-01

Boring	Date	Groundwater Depth (feet bgs)	Groundwater Elevation (feet)[a]
B-01	10/26/2023	> 38	< 126
B-01	11/14/2023	> 38	< 126
B-01	03/07/2024	34.8	129

Note:
a. Vertical datum: NGVD29.
Abbreviations:
bgs = below ground surface
NGVD29 = National Geodetic Vertical Datum of 1929

The groundwater was inferred in each CPT sounding based on the pore pressure dissipation tests. The inferred groundwater levels from the CPT data are presented in Table 4-3.

Table 4-3. Groundwater Levels Inferred from CPT Pore Pressure Dissipation Tests

CPT Sounding	Date	Groundwater Depth (feet, bgs)	Groundwater Elevation (feet)[a]
C-01	08/14/2023	72	92.2
C-02	08/14/2023	60	99.8

Note:
a. Vertical datum: NGVD29.
Abbreviations:
bgs = below ground surface
NGVD29 = National Geodetic Vertical Datum of 1929

5. Limitations

This report has been prepared for the exclusive use of Clean Water Services and Jacobs for specific application to the design, bidding phase, and services during construction for the Durham WRRF Phase 6B Digester Preliminary Design Project. The report has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty, express or implied, is made.

The data contained in this report are based on the geotechnical borings and CPTs advanced during the geotechnical exploration program conducted in 2023. Concurrent and previous geotechnical explorations conducted by others have been referenced. Exploration data indicate subsurface conditions only at specific locations and times, and only to the depths penetrated; they do not reflect strata variations that may exist between such locations. Subsurface conditions and water levels at other locations may differ from conditions occurring at these locations. The nature and extent of variation may not become evident until materials are exposed during construction. The passage of time may result in a change in the conditions at these locations.

The scope of Jacobs's geotechnical services did not include an environmental evaluation regarding the presence or absence of hazardous or toxic materials in the soil or groundwater on or below the site, nor did it include an evaluation of disposal requirements should these materials be encountered.

This report should be made available to prospective contractors for use as factual data only, and not as a warranty of subsurface conditions. If there are changes in the nature, design, or location of the planned facilities, the data contained in this report should not be considered valid unless the changes are reviewed, and the data verified or modified in writing by Jacobs. Jacobs is not responsible for any claims, damages, or liability associated with the interpretations of subsurface data or reuse of the subsurface data without the express written authorization of Jacobs.

6. References

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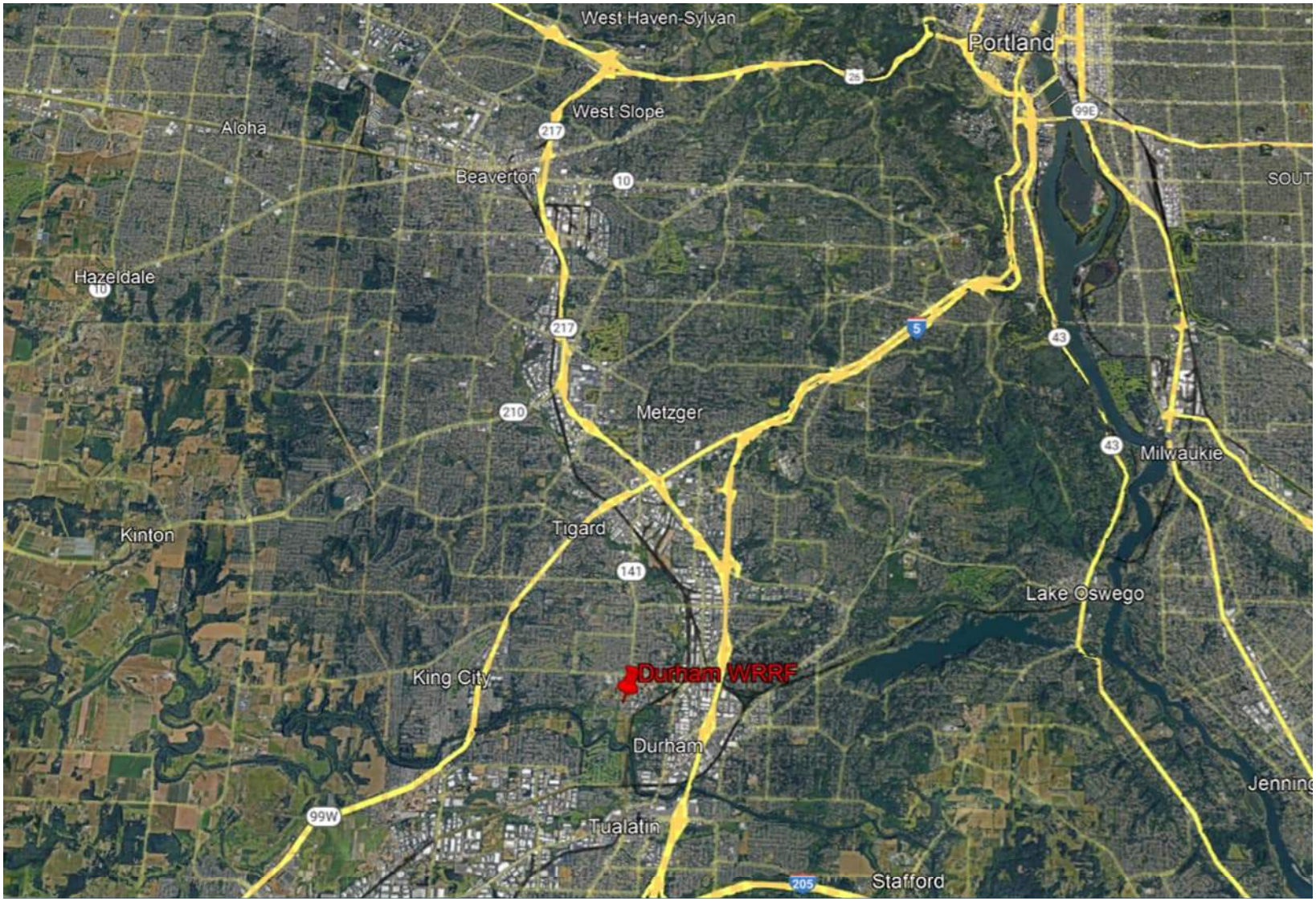
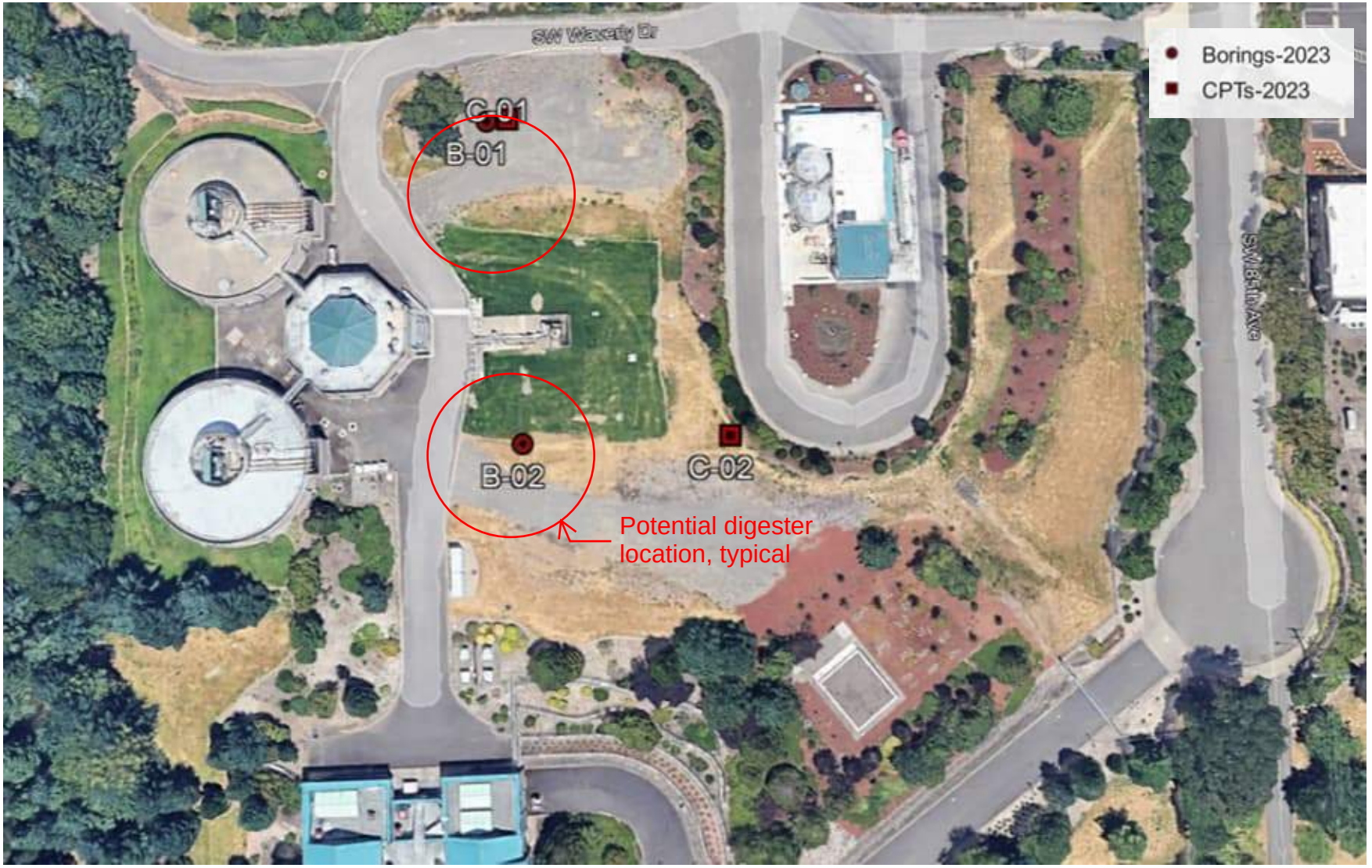
Figures



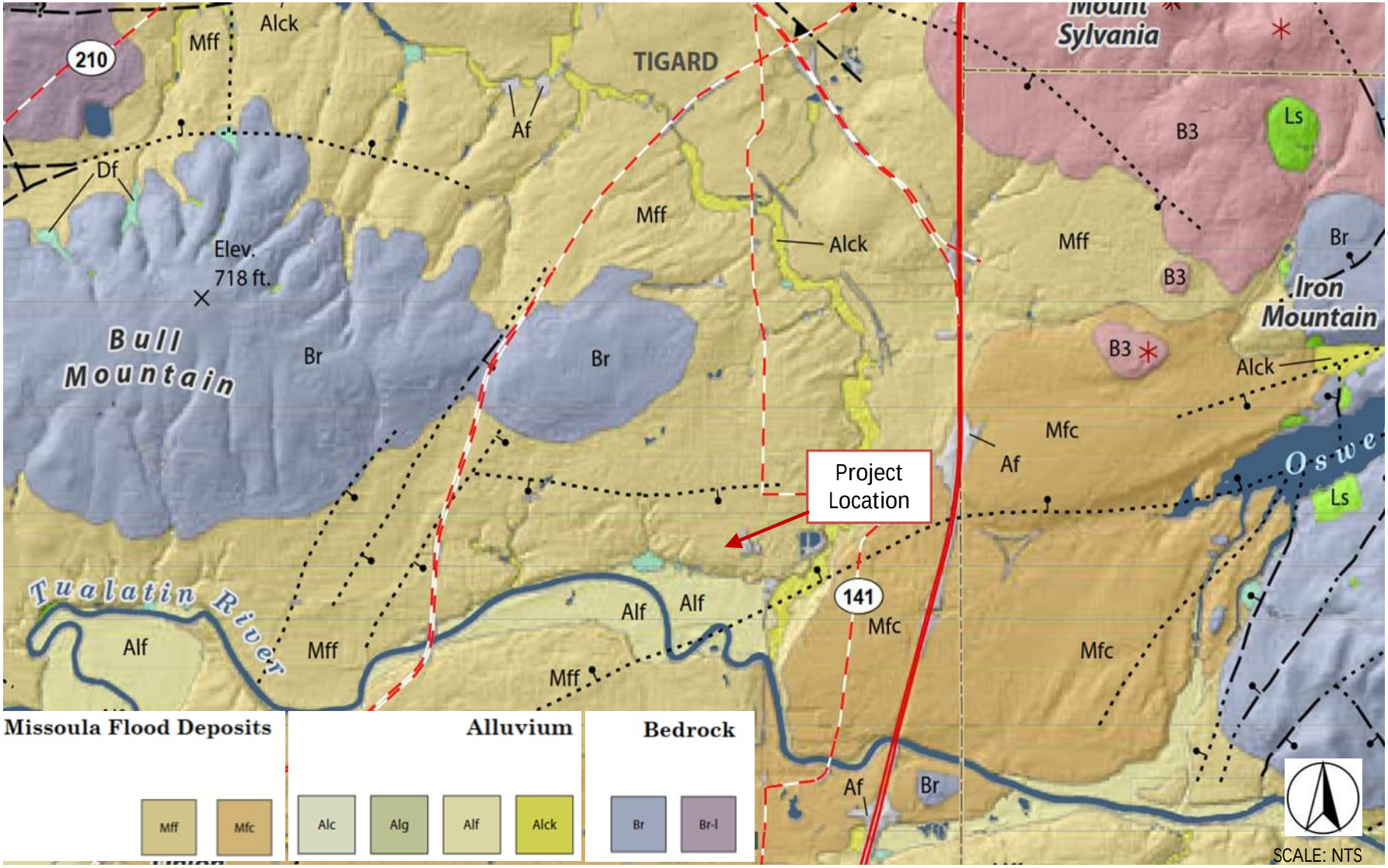
Jacobs	GEOTECHNICAL DATA REPORT Durham WRRF Phase 6B Digester Preliminary Design Project	FIGURE 1
	Tigard, Oregon	
	PROJECT LOCATION	Nov 2023

Source: Figure was created using a map from Google Earth



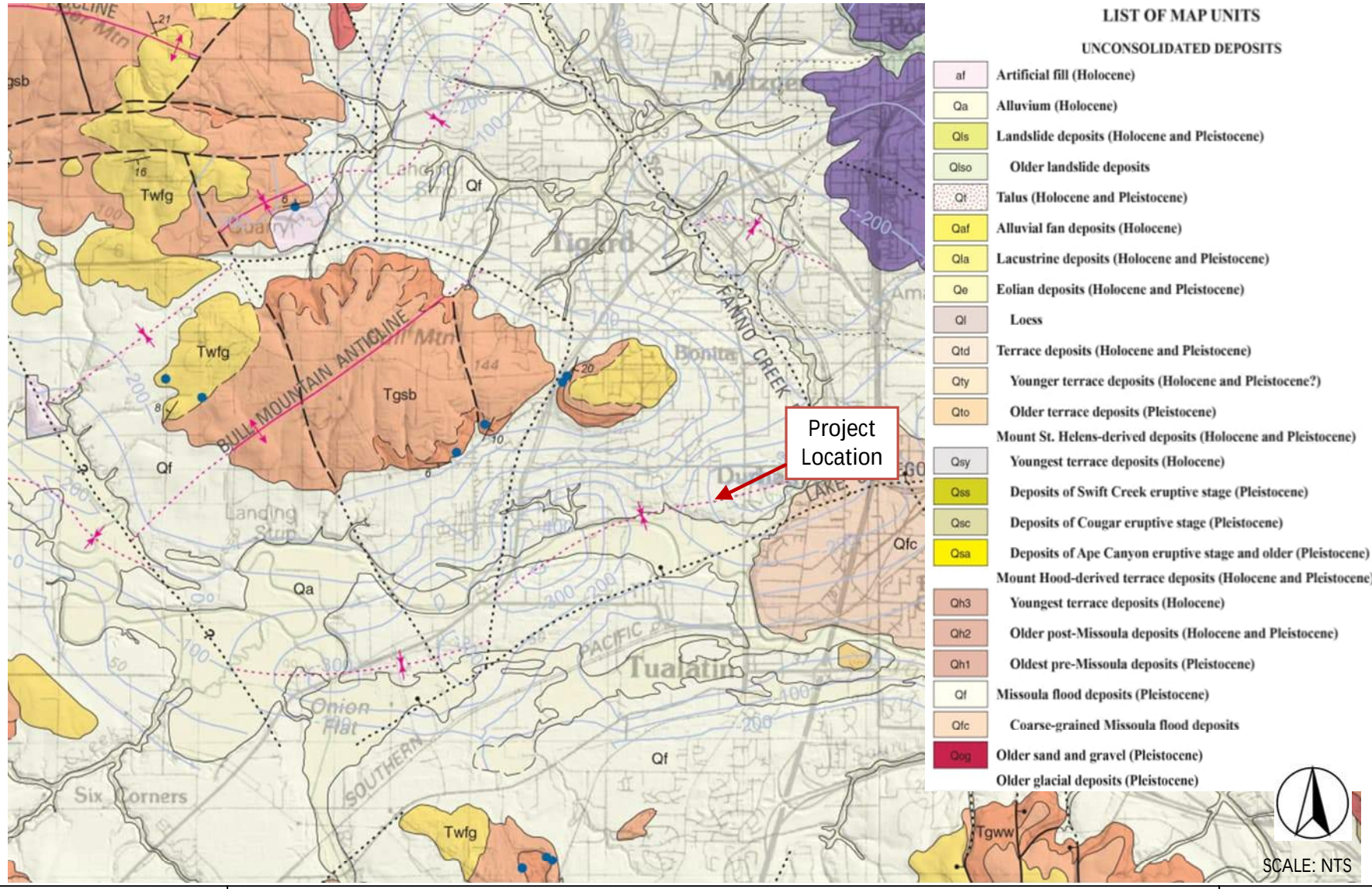
Jacobs	GEOTECHNICAL RECOMMENDATIONS REPORT Durham WRRF Phase 6B Digester Preliminary Design Project	FIGURE 2
	Tigard, Oregon	
	LOCATIONS OF GEOLOGICAL EXPLORATIONS	Nov 2023

Source: Figure was created using a map from Google Earth



Jacobs	GEOTECHNICAL DATA REPORT Durham WRRF Phase 6B Digester Preliminary Design Project	FIGURE 3
	Tigard, Oregon	
	PROJECT SITE GEOLOGY ACCORDING TO OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES	Nov 2023

Source: Ma et al. (2012).



Jacobs	GEOTECHNICAL DATA REPORT Durham WRRF Phase 6B Digester Preliminary Design Project	FIGURE 4
	Tigard, Oregon	
	PROJECT SITE GEOLOGY ACCORDING TO THE U.S. GEOLOGICAL SURVEY	Nov 2023

Source: Wells et al. (2020).

Appendix A
Boring Logs

Boring Log Reference Guide

Abbreviations	
bgs	below ground surface
GS	grab sample
LL	liquid limit
Mn	manganese
PL	plastic limit
PI	plasticity index
PP	field pocket penetrometer
psf	pounds per square foot
S	sonic core sample
SS	split-spoon sample
su	undrained shear strength
tsf	tons per square foot
WC	moisture content
WOH	weight of hammer

Relative Density of Coarse-Grained Soil	
Blows per foot	**Relative Density**
0–4	Very loose
5–10	Loose
11–30	Medium
31–50	Dense
50	Very dense

Source: Sowers 1979

Consistency of Fine-Grained Soil			
Blows per foot	**Consistency**	**Pocket Penetrometer Test (tsf)**	**Torvane Test (tsf)**
<2	Very soft	<0.25	<0.12
2–4	Soft	0.25–0.50	0.12–0.25
5–8	Firm	0.50–1.0	0.25–0.5
9–15	Stiff	1.0–2.0	0.5–1.0
16–30	Very stiff	2.0–4.0	1.0–2.0
30	Hard	>0.4	>0.2

Source: Sowers 1979

Plasticity of Fine-Grained Soil	
Plasticity Index	**Plasticity**
0–3	Nonplastic
3–15	Slightly plastic
15–30	Medium plastic
>30	Highly plastic

Source: EPRI 1990

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 1 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
						POORLEY GRADED GRAVEL WITH SAND (GP) Brown to gray, moist, medium dense, angular particles, less than 10% silt & trace of organics (roots)	Hand-augered the first 5 ft to make sure there is no irrigation line.
						SILT (ML) Brown, moist, soft, low plasticity, ± 5% organic (roots)	
5	5.0						
	6.5	1.30	SS-1	4-5-7 (12)		**SILT (ML)** Brown, moist, stiff, low plasticity, 5-10% fine sand	Started drilling with truck rig #4 and tricone bit diameter 4 7/8" Pocket Penetrometer (PP)=0.5 tsf
	8.5	1.25	ST-2				Shelby Tube (ST) Pressure= 250 psi for the first 1 ft and for the second foot, the pressure gradually increased to 750 psi & then refusal
10	10.0	1.10	SS-3	5-5-6 (11)		**SANDY SILT (ML)** Brown, wet, stiff, low plasticity, 30-40% fine sand	Lab Results for SS-3: Water Content (WC)=32.2% Atterberg Limits: LL=36.3, PL=27.9, PI=8.4 P200: Fines Content=62.8%, Gravel=0%
	11.5	1.10	SS-4	5-6-6 (12)		**SILTY SAND (SM)** Dark brown, wet, medium dense, fine sand	
15	15.0						
	16.5	0.60	SS-5	6-4-3 (7)		**POORLY GRADED SAND WITH SILT (SP-SM)** Dark brown, wet, loose, coarse to fine sand	Lab Results for SS-5: WC=27% Atterberg Limits: LL=NV, PL=NP, PI=NP P200: Fines Content=27%, Gravel=0%
20							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 2 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	20.0	1.30	SS-6	2-4-9 (13)		SS-6-A, 20-21 ft: **LEAN CLAY (CL)** Brown, wet, stiff, medium plasticity	PP=0.5 tsf
	21.5					SS-6-B, 21-21.5 ft: **POORLY GRADED SAND WITH SILT (SP-SM)** Dark brown, wet, medium dense, coarse to fine sand	
25	25.0	1.00	SS-7	8-9-15 (24)		**SILTY, CLAYEY SAND (SC-SM)** Dark brown, wet, medium dense, coarse to fine sand, 1 inch lense of lean clay similar to SS-6-A	Lab Results for SS-7: WC=23.7% P200: Fines Content=31.5%, Gravel=0%
	26.5						
30	30.0	0.70	SS-8	9-12-16 (28)		SS-8-A, 30-31 ft: **SILTY SAND (SM)** Dark gray, wet, medium dense, trace of gravel	
	31.5					SS-8-B, 31-31.5 ft: **POORLY GRADED SAND (SP)** Dark gray, wet, medium dense, coarse sand with trace orange color spots	
35	35.0	1.10	SS-9	14-16-15 (31)		**SILTY SAND (SM)** Dark gray with some orange sports, wet, dense	
	36.5						
40							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 3 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
40.0							
	1.00	SS-10	12-11-11 (22)		SS-10-A, 40-41 ft: **SILTY SAND (SM)** Similar to SS-9	Lab Results for SS-10-A: WC=22.1% Atterberg Limits: LL=NV, PL=NP, PI=NP P200: Fines Content=24.2%, Gravel=0%
41.5						SS-10-B, 41-41.5 ft: **SILT (ML)** Brown, wet, very stiff, low plasticity	
	1.00	ST-11					ST Pressure= 750 psi, 1 ft push and then refusal
42.5							
45 45.0							
	1.50	SS-12	4-7-9 (16)		**FAT CLAY (CH)** Brown with balck and orange spots, wet, very stiff, high-plasticity, ± 5% fine sand & silt	PP=1.5 tsf
46.5							
	1.10	ST-13			**LEAN CLAY (CL)** Dark tan with iron staining, low plasticity, trace of gravel	ST Pressure= 400-500 psi Lab Results for ST-13: WC=33.7% Atterberg Limits: LL=41.2, PL=15, PI=26.2 P200: Fines Content=65.3%, Gravel=0.8% Unconfined Compression Test and Shelby Tube Description, see lab results
48.5							
50 50.0							
	1.50	SS-14	7-8-11 (19)		**SILTY CLAY (CL-ML)** Light brown with black & orange spots, wet, very stiff, medium plasticity, trace of gravel, ± 5% sand	PP= 2 tsf
51.5							
55 55.0							
	1.50	SS-15	5-7-12 (19)		**LEAN CLAY (CL)** Light brown and gray with black & orange spots, wet, very stiff, medium plasticity, ± 5% sand	PP=1 tsf Lab Results for SS-15: WC=38.2% Atterberg Limits: LL=48.8, PL=25.6, PI=23.2
56.5							
	1.60	ST-16					ST Pressure=350-750 psi, 20 inches push
58.2							
60							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 4 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	60.0					**SILT WITH SAND (ML)**	
		1.50	SS-17	11-9-13 (22)		Orange bown and gray, wet, very stiff, low plasticity, ± 15% clay	
	61.5						
65	65.0						
		1.50	SS-18	10-13-14 (27)		SS-18-A, 65-66 ft: **SILT (ML)** Orange brown with zones of gray, wet, very stiff, low plasticity	PP=2.5, 3 tsf Lab Results for SS-18-A: WC=38.9% Atterberg Limits: LL=43.9, PL=26.7, PI=17.2
	66.5					SS-18-B, 66-66.5 ft: **FAT CLAY (CH)** Gray to greenish blue color, wet, very stiff, high plasticity	
70	70.0						
		1.50	SS-19	10-15-16 (31)		**FAT CLAY (CH)** Gray to greenish blue color, wet, very stiff, high plasticity, trace of organic (wood)	PP=1.5, 2 tsf
	71.5						
75	75.0						
		1.50	SS-20	8-11-13 (24)		**FAT CLAY (CH)** Greenish blue color, wet, very stiff, meduim to high plasticity, ± 15% gravel	
	76.5						
80							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 5 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	80.0						
		1.50	SS-21	9-9-13 (22)		**FAT CLAY (CH)** Greenish blue color, wet, very stiff, high plasticity, trace of organic (wood)	PP=2 tsf Lab Results for SS-21: WC=35.5% Atterberg Limits: LL=57.2, PL=23.8, PI=33.4 P200: Fines Content=63.9%, Gravel=0%
	81.5						
85	85.0						
		1.50	SS-22	11-11-15 (26)		**FAT CLAY (CH)** Similar to SS-21 except no organic	PP=2.5 tsf
	86.5						
90	90.0						
		1.50	SS-23	11-12-17 (29)		**FAT CLAY (CH)** Similar to SS-21 except the color, more gray	Stopped drilling at 91.5' due to malfuntion of truck rig#4 and replaced with CME 75, rig #5
	91.5						
95	95.0						
		1.50	SS-24	9-11-16 (27)		**FAT CLAY (CH)** Similar to SS-21	PP=3 tsf
	96.5						
100							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-01 SHEET 6 OF 6

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640049.38 N, 7620132.03 E)

ELEVATION : 163.79 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #4 & #5, Tricone Bit Diameter 4 7/8", Hammer Efficiency (Rig #4)=76.8%, Hammer Efficiency (Rig#5)=84.1%

WATER DEPTH : Not Recorded START : 8/21/23 10:15 END : 8/22/23 14:00 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
100.0						**FAT CLAY (CH)**	PP= 0.75 tsf
	1.50	1.50	SS-25	28-13-13 (26)		Dark gray, wet, very stiff, high plasticity, 10-15% gravel & lenses of cementation	Lab Results for SS-10-A: WC=38.0% Atterberg Limits: LL=50.1, PL=26.4, PI=23.7
101.5						End of boring at 101.5 ft below ground surface.	2" PVC standpipe piezometer and 12" diameter monument are installed on 08/23/23 Flushed the well with clean water, but silty materials clogged the well at 50-60 ft below ground surface (bgs). The driller used tremie pipe to flush the well, but didn't help with the blockage. Due to this issue the screen was not installed at 80-100 ft bgs; instead, it was installed at 30-40 ft bgs. 65-100 ft bgs: grout 41.5-65 ft bgs: bentonite 40-41.5 ft bgs: sand 30-40 ft bgs: screen 27.2-30 bgs: sand 27.2 bgs to top: bentonite pallet & plug Well tag No: #L150543 Satrt card No: #1070804
105							VWP is installed on 10/26/23, Base of VWP is at 36.85 ft bgs, R0(field)=9133.0285, Tem (F)=46 degrees, Barometer (inHg)=30.26 Geokon VWP 4500S-700KPA, Unvented, Serial No. 2267478 Geokon datalogger 8943-01C-WP, Geonet waterproof logger, Single channel, serial No. 2311480
110							
115							
120							

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PROJECT NUMBER:	BORING NUMBER:
D3704504	B-02 SHEET 1 OF 4

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (639881.52 N, 7620148.01 E)

ELEVATION : 158.95 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #5, Hammer Efficiency=84.1%

WATER DEPTH : Not Recorded START : 8/24/23 08:20 END : 8/24/23 14:05 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
0						**CLAYEY GRAVEL (GC)** Light brown, dry, medium dense, angular gravel particles with the size of 0.5-1 inch	Started hand-augereing the first 5 ft to make sure there is no irrigation line but it was stopped at 2 ft due to the presense of gravel and cobbles. The soil at 2 ft was slightly moist and had trace of cobbles. The depth from 2-5 ft was drilled.
5	5.0						
	6.5	1.20	SS-1	6-10-6 (16)		**CLAYEY SAND (SC)** Dark gray, moist, medium dense, trace of gravel with the size of 0.5-1 inch and angular, trace of organic (wood), fine sand	Started drilling with truck rig #5 and tricone bit diameter 4 7/8" Pocket Penetrometer (PP)=2 tsf
	7.5	1.00	ST-2				Shelby Tube (ST) Pressure= 700 psi, only 1 ft push and then refusal
10	10.0						
	11.5	1.10	SS-3	7-5-4 (9)		**CLAYEY SAND (SC)** Similar to SS-1 except loose and more organic	Lab Results for SS-3: Water Content (WC)=27.8% Atterberg Limits: LL=29.6, PL=21.3, PI=8.3 P200: Fines Content=45.3%, Gravel=0%
15	15.0						
	16.5	1.00	SS-4	0-1-2 (3)		SS-4-A, 15-16.2 ft: **CLAYEY SAND (SC)** Dark gray, wet very loose, trace of gravel with zones of cementation	
	17.8	1.10	ST-5			SS-4-B, 16.2-16.5 ft: **ORGANIC SOIL(OH)** Dark brown, wet, very loose, high plasticity **CLAYEY, SILTY SAND (SC-SM)** Dark brown, high plasticity	ST Pressure= 400 psi for the first 1 ft, 700 psi for 4 inches push, and then refusal Lab Results for ST-5: WC=59.8% Atterberg Limits: LL=77.2, PL=52.6, PI=24.6 P200: Fines Content=48.2%, Gravel=0% Consolidation Test and Unconfined Compression Test, and Shelby Tube Description, see lab results
20							

Jacobs

PROJECT NUMBER:	BORING NUMBER:
D3704504	B-02 SHEET 2 OF 4

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (639881.52 N, 7620148.01 E)

ELEVATION : 158.95 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #5, Hammer Efficiency=84.1%

WATER DEPTH : Not Recorded START : 8/24/23 08:20 END : 8/24/23 14:05 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	20.0	1.40	SS-6	2-2-3 (5)		**SILTY CLAY (CL-ML)** Brown, wet, loose to very loose, low to medium plasticity	PP=0.25 tsf Lab Results for SS-6: WC=26.4% Atterberg Limits: LL=25.8, PL=20.9, PI=4.9
	21.5	1.00	ST-7				ST Pressure= 400 psi for the first 1 ft, 700 psi for 10 inches push, and then refusal
	23.3						
25	25.0	1.20	SS-8	2-2-4 (6)		**SANDY SILT (ML)** Brown & Gray, wet, firm, coarse to fine sand	Lab Results for SS-8: WC=34.7% Atterberg Limits: LL=30.8, PL=26.4, PI=4.4 P200: Fines Content=54.7%, Gravel=0%
	26.5						
30	30.0	1.00	SS-9	11-12-14 (26)		**POORLY GRADED SAND (SP)** Gray with orange particles, wet, medium dense, medium coarse sand	
	31.5						
35	35.0	1.10	SS-10	12-12-11 (23)		**POORLY GRADED SAND WITH CLAY (SP-SC)** Gray with orange particles, wet, medium dense, medium coarse sand	
	36.5						
40							

Jacobs

PROJECT NUMBER:	BORING NUMBER:
D3704504	B-02 SHEET 3 OF 4

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (639881.52 N, 7620148.01 E)

ELEVATION : 158.95 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #5, Hammer Efficiency=84.1%

WATER DEPTH : Not Recorded START : 8/24/23 08:20 END : 8/24/23 14:05 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
40.0							
	1.10	SS-11	12-12-9 (21)		**POORLY GRADED SAND WITH CLAY (SP-SC)** Similar to SS-10 except brown and more fine sand	Driller changed the drag bit to 3 7/8" Lab Results for SS-11: WC=21.5% Atterberg Limits: LL=NV, PL=NP, PI=NP P200: Fines Content=41.4%, Gravel=0%
41.5						
45 45.0						
	1.30	SS-12	7-5-7 (12)		SS-12-A, 45-45.8 ft: **SANDY SILT WITH GRAVEL (ML)** Brown and gray, wet, stiff, low plasticity	PP=0.25 tsf
46.5					SS-12-B, 45.8-46.5 ft: **FAT CLAY (CH)** Brown, wet, stiff, medium to high plasticity	
	0.30	ST-13			**SILTY SAND (SM)** Brown, coarse sand	ST pressure= 700 psi for 9 inches and then refusal Lab Results for ST-13: WC=25.1% Atterberg Limits: LL=NV, PL=NP, PI=NP P200: Fines Content=21.4%, Gravel=5.1% Shelby Tube Description, see lab results
47.3						
50 50.0						
	1.50	SS-14	7-2-4 (6)		SS-14-A, 50-50.25 ft: **POORLY GRADED SAND (SP)** Gray with orange particles, wet, medium dense, medium coarse sand	Lab Results for SS-14-B: WC=29.9% Atterberg Limits: LL=30.7, PL=21.4, PI=9.3 P200: Fines Content=74.3%, Gravel=0.4%
51.5					SS-14-B, 50.25-51.5 ft: **LEAN CLAY WITH SAND (CL)** Brown, wet, firm, low plasticity, trace of coarse sand and tarce of organic	
55 55.0						
	1.30	SS-15	6-9-12 (21)		**FAT CLAY (CH)** Gray to greenish blue color, wet, very stiff, high plasticity, ~10% medium coarse sand, trace of silt	PP=2.5, 3 tsf
56.5						
60						

Jacobs

PROJECT NUMBER:	BORING NUMBER:
D3704504	B-02 SHEET 4 OF 4

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (639881.52 N, 7620148.01 E)

ELEVATION : 158.95 ft DRILLING CONTRACTOR : Western States Drilling

DRILLING METHOD AND EQUIPMENT : Mud Rotary, CME 75, Truck Rig #5, Hammer Efficiency=84.1%

WATER DEPTH : Not Recorded START : 8/24/23 08:20 END : 8/24/23 14:05 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	60.0	1.50	SS-16	7-9-12 (21)		**FAT CLAY (CH)** Similar to SS-15 except trace of organic & more silt (20-30%)	PP=2.5 tsf
	61.5						
65	65.0	1.50	SS-17	6-8-11 (19)		**FAT CLAY (CH)** Gray to greenish blue color, wet, very stiff, high plasticity, trace of organic	PP=2 tsf Lab Results for SS-17: WC=30.0% Atterberg Limits: LL=60.1, PL=18.0, PI=42.1
	66.5						
70	70.0	1.50	SS-18	5-5-7 (12)		SS-18-A, 70-70.3 ft: **FAT CLAY (CH)** Brown and gray, wet, stiff, high plasticity SS-18-B, 70.3-71.5 ft: **ELASTIC SILT WITH SAND (MH)** Brown and gray with greenish blue zones, wet, stiff, high to medium plasticity	PP=1, 1.5 tsf
	71.5						
75	75.0	1.50	SS-19	4-5-7 (12)		**SILTY SAND (SM)** Dark gray with zones of brown and greenish blye color, wet, medium dense, medium plasticity, trace of gravel (size of 0.5 inch)	PP=0.5 tsf Lab Results for SS-19: WC=38.5% P200: Fines Content=36.9%, Gravel=0.9%
	76.5					End of Boring at 76.5 ft below ground surface.	
80							

Jacobs

PROJECT NUMBER:	BORING NUMBER:
D3704504	C-01 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (640050.51 N, 7620149.91 E)

ELEVATION : 164.20 ft DRILLING CONTRACTOR : Oregon Geotechnical Explorations

DRILLING METHOD AND EQUIPMENT : Hand Auger

WATER DEPTH : Not Recorded START : 8/14/23 08:15 END : 8/14/23 11:30 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
0.0						**POORLY GRADED GRAVEL WITH SILT (GP-GM)** Gray & brown, moist, medium dense, trace of organic (roots), angular coarse gravel with the maximum size of 2-3 inches, low plasticity for clay and silt, ±10% silt, 2-5% clay	It was planned to hand-auger the first 5ft to make sure there is no irrigation line. However, hand auger was stopped at 2.5 ft below the ground surface (bgs) due to the presense of coarse gravel.
2.5							End of CPT/C-01 at 85.3 ft bgs. Refer to CPT/C-01 log for more information.
5							
10							
15							
20							

Jacobs

PROJECT NUMBER:	BORING NUMBER:
D3704504	C-02 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : Durham WRRF Phase 6B Digester Preliminary Design Project LOCATION : SW 85th Ave, Tigerd, OR (639871.65 N, 7620243.93 E)

ELEVATION : 159.79 ft DRILLING CONTRACTOR : Oregon Geotechnical Explorations

DRILLING METHOD AND EQUIPMENT : Hand Auger

WATER DEPTH : Not Recorded START : 8/14/23 09:55 END : 8/14/23 13:05 LOGGER : A. Biniyaz

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft) / RECOVERY (ft) / TYPE/ NUMBER	PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
0.0				**GRAVELLY SILTY CLAY (CL-ML)** Light brown, dry, low-medium plasticity, 30% angular to subangular gravel with the sizes up to 2.5-3 inches, trace of organic (roots and wood pieces)	It was planned to hand-auger the first 5 ft to make sure there is no irrigation line. However, hand auger was stopped at 3.5 ft below the ground surface (bgs) due to the presense of coarse gravel.
0.5				**CLAYEY GRAVEL (GC)** Light brown, moist, angular and coarse gravel, trace of organic (roots and wood pieces)	
3.5					End of C-02 at 80.4 ft bgs. Refer to CPT/C-02 log for more information.
5					
10					
15					
20					

Appendix B
Geotechnical Exploration Photographs

CME-75 Track-Mounted Rig #4

CME-75 Track-Mounted Rig #5

DRILL RIGS FOR GEOTECHNICAL BORINGS
Geotechnical Data Report
Clean Water Services
Durham WRRF 6B Digester Preliminary Design

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BORING B-01
Geotechnical Data Report
Clean Water Services
Durham WRRF 6B Digester Preliminary Design

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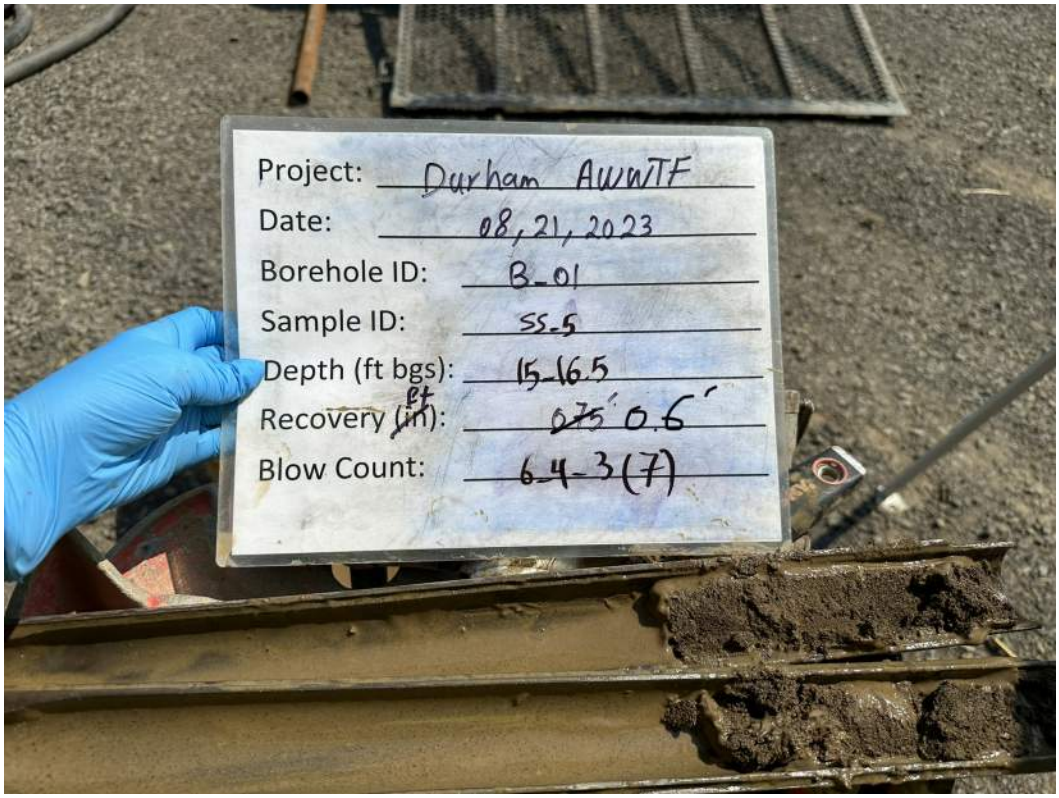

BORING B-01
Geotechnical Data Report
Clean Water Services
Durham WRRF 6B Digester Preliminary Design

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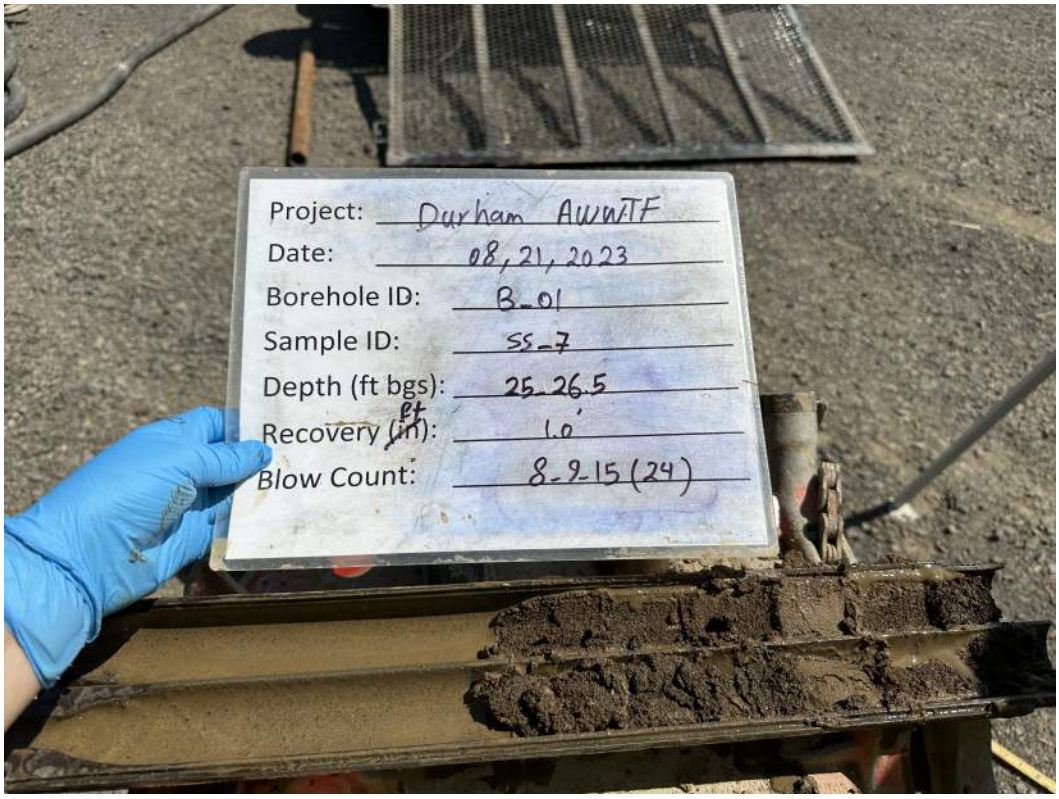

BORING B-01
Geotechnical Data Report
Clean Water Services
Durham WRRF 6B Digester Preliminary Design

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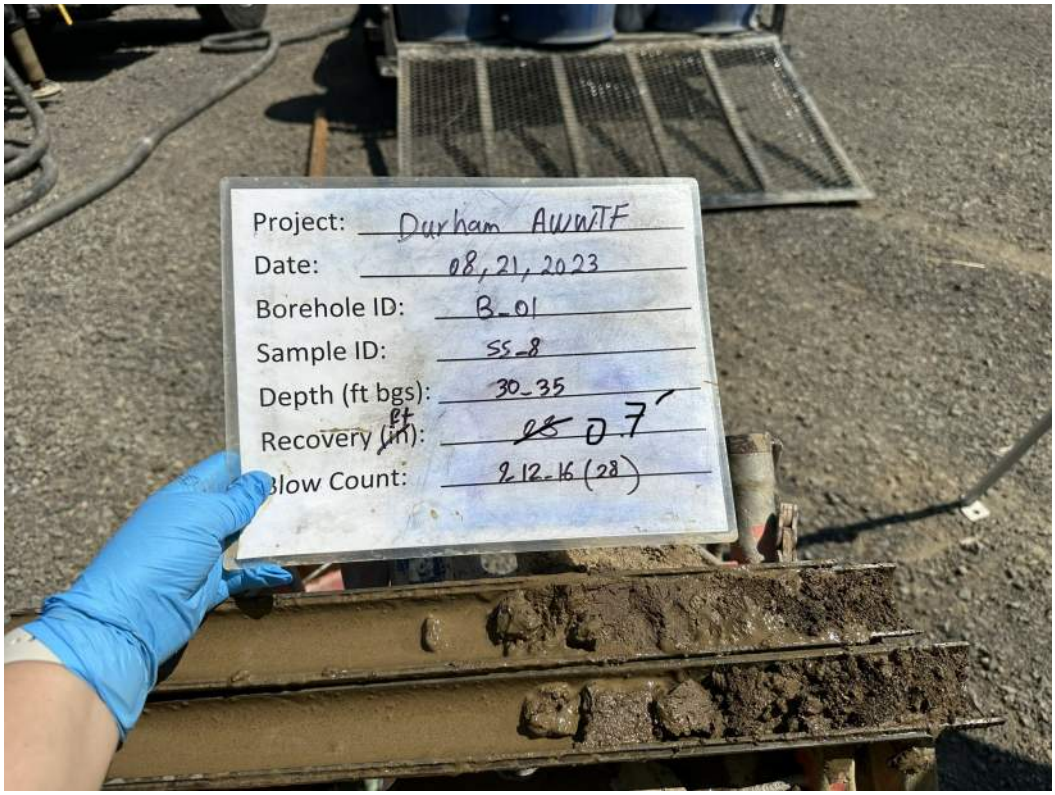

BORING B-01
Geotechnical Data Report
Clean Water Services
Durham WRRF 6B Digester Preliminary Design

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Clean Water Services
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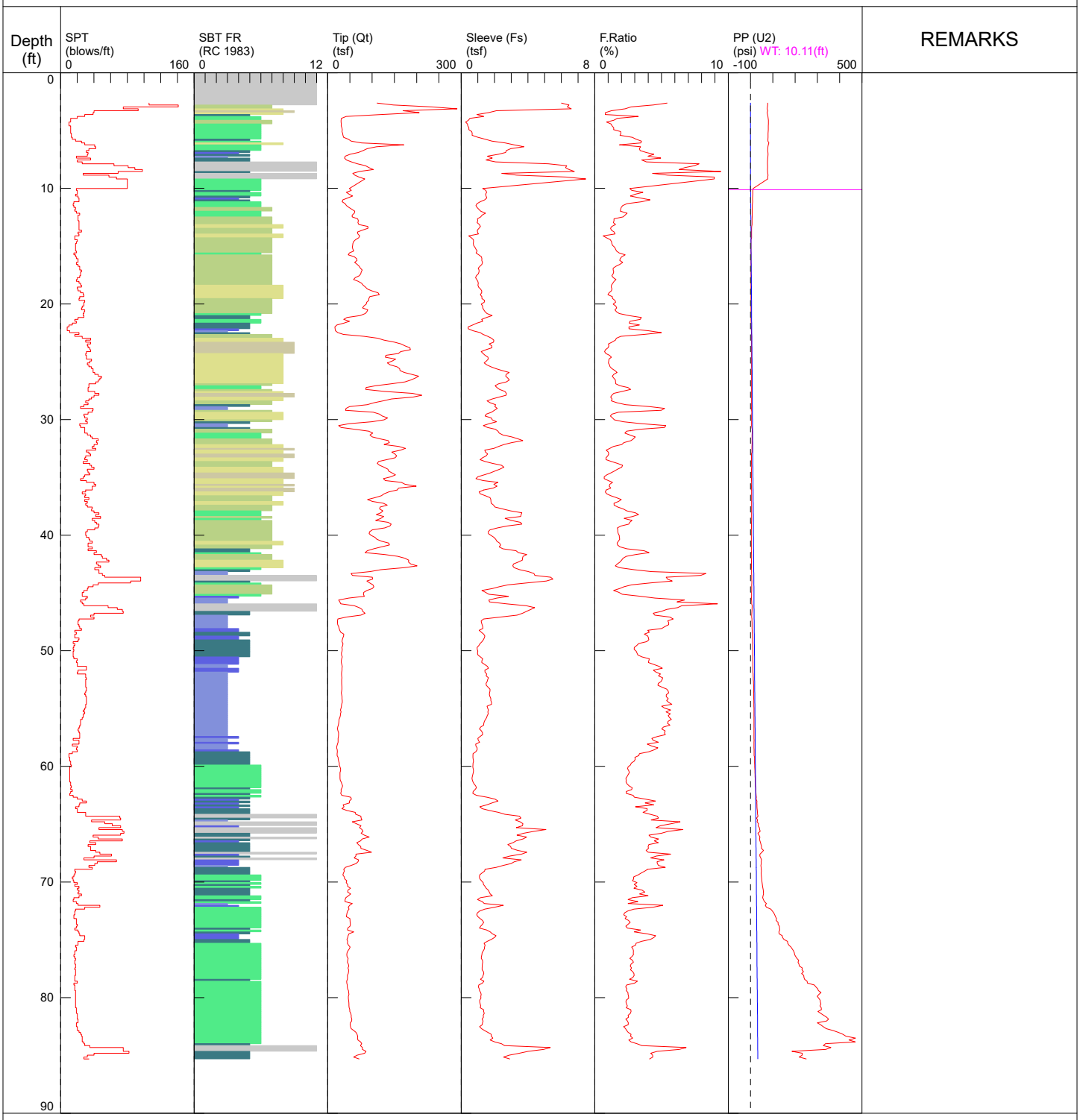
Appendix C
Cone Penetration Test Data

Jacobs / CPT C-01 / 16580 SW 85th Ave Tigard

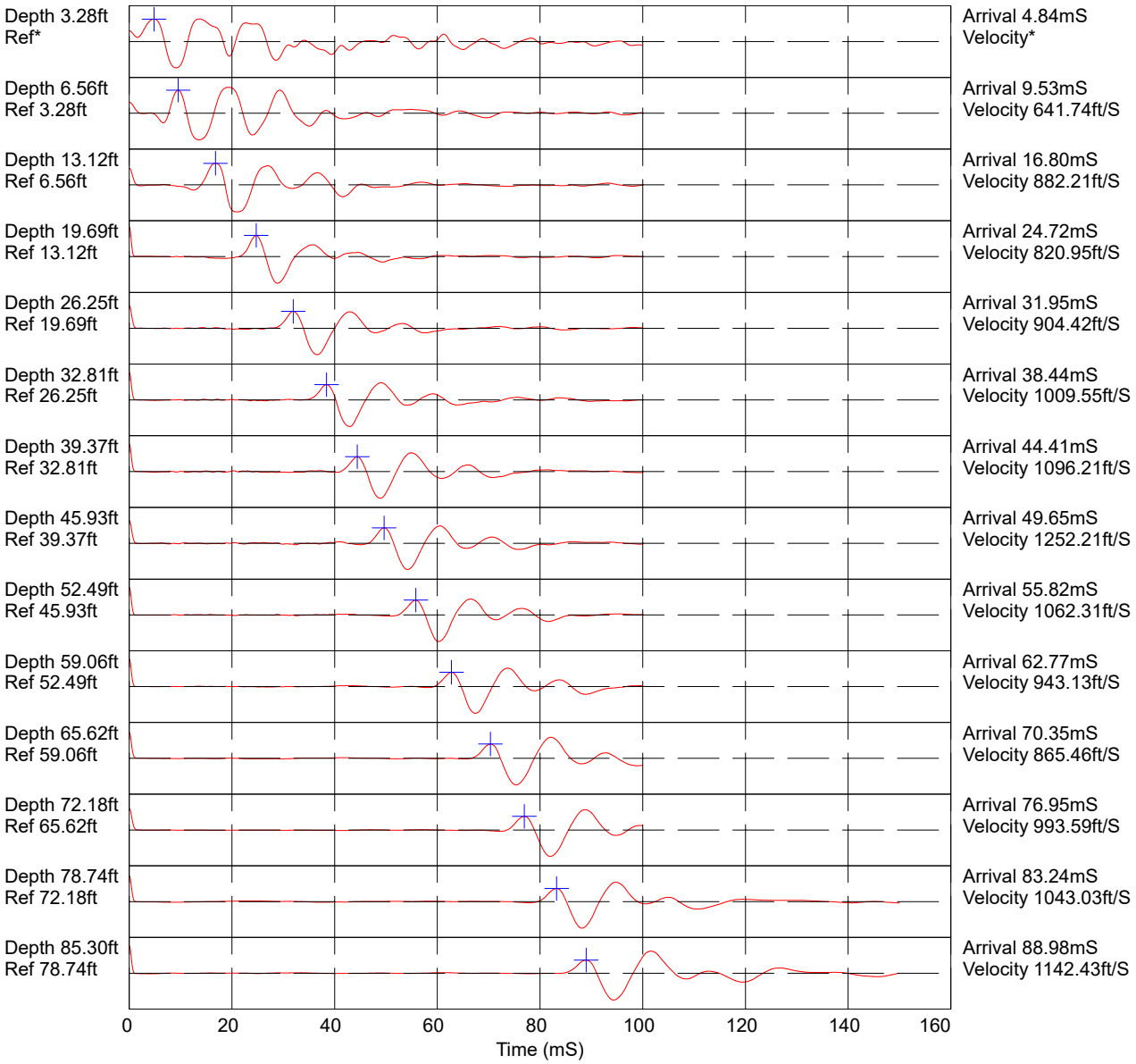
OPERATOR: OGE BAK
CONE ID: DDG1415
TEST DATE: 8/14/2023 9:45:55 AM
TOTAL DEPTH: 85.302 ft



1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

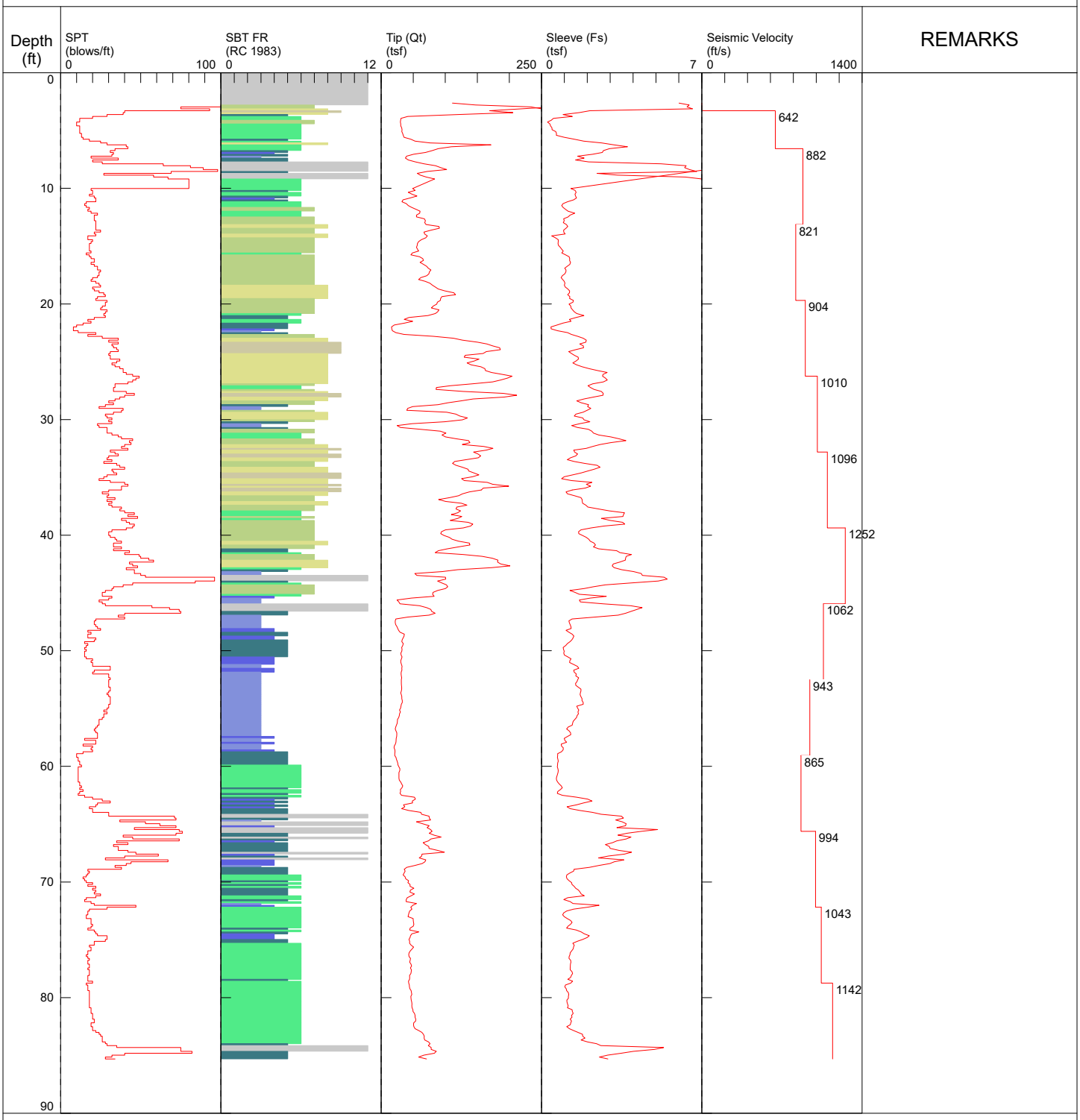
COMMENT: Jacobs / CPT C-01 / 16580 SW 85th Ave Tigard



Hammer to Rod String Distance (ft): 2.04
* = Not Determined

Jacobs / CPT C-01 / 16580 SW 85th Ave Tigard

OPERATOR: OGE BAK
CONE ID: DDG1415
TEST DATE: 8/14/2023 9:45:55 AM
TOTAL DEPTH: 85.302 ft

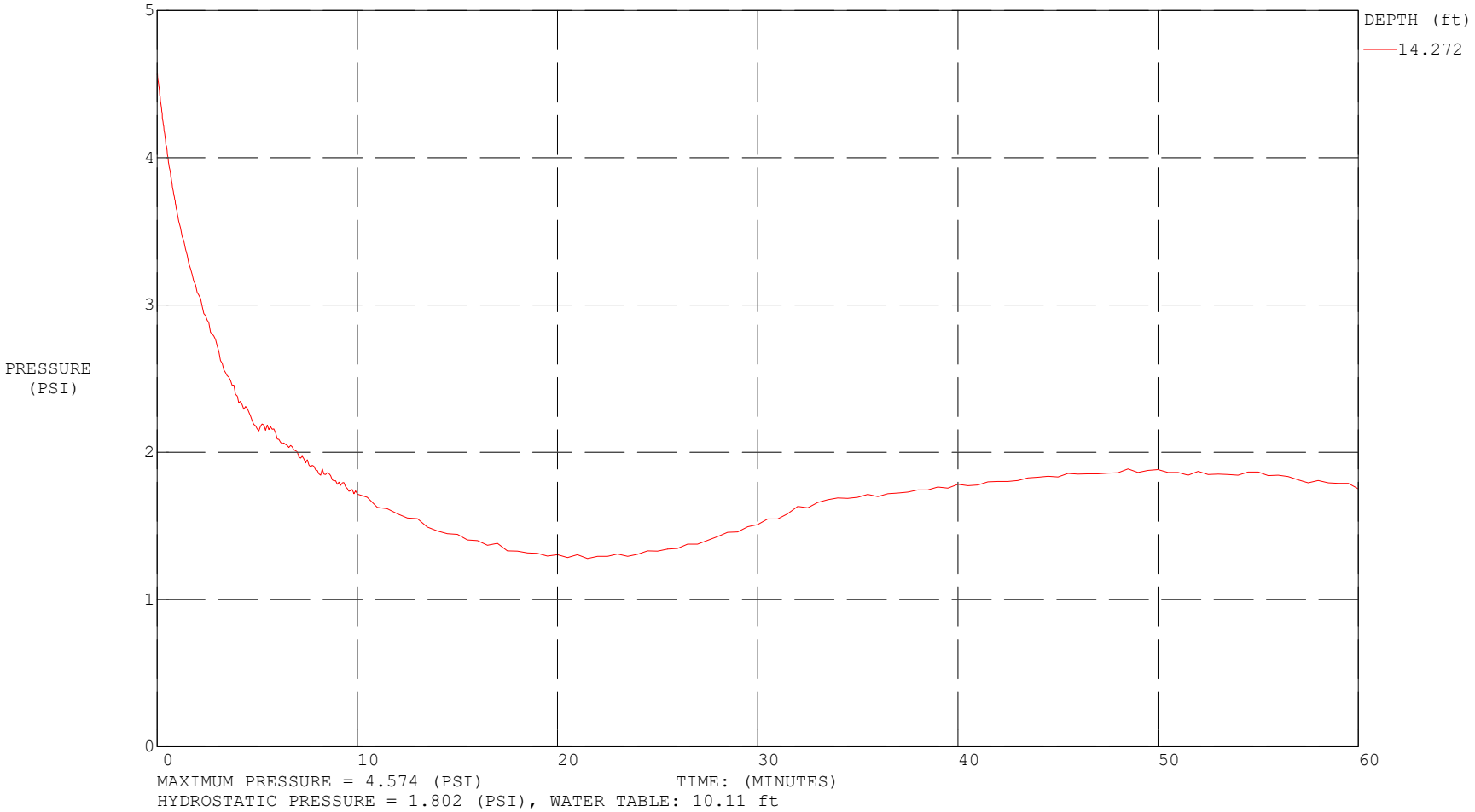


1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: Jacobs / CPT C-01 / 16580 SW 85th Ave Tigard

CONE ID: DDG1415
TEST DATE: 8/14/2023 9:45:55 AM



MAXIMUM PRESSURE = 4.574 (PSI)
HYDROSTATIC PRESSURE = 1.802 (PSI), WATER TABLE: 10.11 ft

Jacobs / CPT C-01 / 16580 SW 85th Ave Tigard

OPERATOR: OGE BAK
CONE ID: DDG1415
TEST DATE: 8/14/2023 9:45:55 AM
TOTAL DEPTH: 85.302 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
2.625	110.99	6.0045	5.410	76.621	106	11	very stiff fine grained (*)
2.789	147.38	6.4486	4.375	76.687	141	11	very stiff fine grained (*)
2.953	233.71	6.3544	2.719	75.310	75	7	silty sand to sandy silt
3.117	290.57	6.5909	2.268	73.920	93	7	silty sand to sandy silt
3.281	169.02	2.1113	1.249	76.654	40	8	sand to silty sand
3.445	205.50	1.6406	0.798	74.122	39	9	sand
3.609	120.23	0.9411	0.783	76.221	29	8	sand to silty sand
3.773	41.45	1.3463	3.248	77.887	20	5	clayey silt to silty clay
3.937	30.91	0.5224	1.690	78.613	12	6	sandy silt to clayey silt
4.101	30.18	0.4267	1.414	80.140	12	6	sandy silt to clayey silt
4.265	30.00	0.2625	0.875	80.152	10	7	silty sand to sandy silt
4.429	30.60	0.3709	1.212	79.974	10	7	silty sand to sandy silt
4.593	30.41	0.3941	1.296	79.783	12	6	sandy silt to clayey silt
4.757	31.99	0.4560	1.426	79.576	12	6	sandy silt to clayey silt
4.921	32.63	0.4588	1.406	79.274	12	6	sandy silt to clayey silt
5.085	32.14	0.6227	1.937	78.858	12	6	sandy silt to clayey silt
5.249	33.50	0.6531	1.950	78.429	13	6	sandy silt to clayey silt
5.413	34.36	0.6472	1.884	78.467	13	6	sandy silt to clayey silt
5.577	35.66	0.9997	2.803	78.375	14	6	sandy silt to clayey silt
5.741	46.36	1.4359	3.097	77.801	18	6	sandy silt to clayey silt
5.906	52.71	1.8397	3.490	77.870	25	5	clayey silt to silty clay
6.070	76.28	2.6280	3.445	82.206	29	6	sandy silt to clayey silt
6.234	171.18	3.1621	1.847	79.310	41	8	sand to silty sand
6.398	109.65	3.7526	3.423	77.663	42	6	sandy silt to clayey silt
6.562	88.79	2.9656	3.340	77.497	34	6	sandy silt to clayey silt
6.726	79.79	2.7064	3.392	76.409	31	6	sandy silt to clayey silt
6.890	69.01	2.6549	3.847	77.784	33	5	clayey silt to silty clay
7.054	50.44	2.2307	4.423	78.151	32	4	silty clay to clay
7.218	39.54	1.5741	3.981	77.744	19	5	clayey silt to silty clay
7.382	37.69	1.8608	4.937	76.840	36	3	clay
7.546	42.27	1.4879	3.519	75.988	20	5	clayey silt to silty clay
7.710	53.41	2.0623	3.862	75.638	26	5	clayey silt to silty clay
7.874	66.80	5.2194	7.814	75.381	64	11	very stiff fine grained (*)
8.038	84.90	6.3185	7.443	75.895	81	11	very stiff fine grained (*)
8.202	92.68	6.2469	6.740	75.812	89	11	very stiff fine grained (*)
8.366	102.23	6.4582	6.317	75.755	98	11	very stiff fine grained (*)
8.530	71.79	6.7748	9.436	75.971	69	11	very stiff fine grained (*)
8.694	56.29	2.4294	4.316	77.135	27	5	clayey silt to silty clay
8.858	60.94	3.3172	5.443	78.118	58	11	very stiff fine grained (*)
9.022	70.29	6.2874	8.945	76.902	67	11	very stiff fine grained (*)
9.186	83.29	7.4506	8.945	76.478	80	11	very stiff fine grained (*)
10.007	49.00	1.2856	2.624	11.234	19	6	sandy silt to clayey silt
10.171	53.07	1.4696	2.769	9.652	20	6	sandy silt to clayey silt
10.335	42.11	1.5163	3.601	9.433	20	5	clayey silt to silty clay
10.499	48.15	1.4598	3.032	9.550	18	6	sandy silt to clayey silt
10.663	55.89	1.4871	2.661	8.936	21	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.827	45.28	1.5287	3.376	8.731	22	5	clayey silt to silty clay
10.991	33.98	1.4044	4.133	8.553	22	4	silty clay to clay
11.155	32.44	1.1377	3.507	8.848	16	5	clayey silt to silty clay
11.319	39.16	0.9440	2.410	8.262	15	6	sandy silt to clayey silt
11.483	42.19	0.8801	2.086	7.803	16	6	sandy silt to clayey silt
11.647	47.44	0.9411	1.984	7.601	18	6	sandy silt to clayey silt
11.811	54.09	1.0465	1.935	7.425	17	7	silty sand to sandy silt
11.975	60.66	1.1615	1.915	7.258	19	7	silty sand to sandy silt
12.139	59.96	1.4515	2.421	7.144	23	6	sandy silt to clayey silt
12.303	55.04	1.2480	2.268	7.091	21	6	sandy silt to clayey silt
12.467	55.01	1.1629	2.114	7.080	21	6	sandy silt to clayey silt
12.631	67.26	0.9682	1.440	6.477	21	7	silty sand to sandy silt
12.795	68.98	0.9912	1.437	6.337	22	7	silty sand to sandy silt
12.959	67.99	0.9490	1.396	6.237	22	7	silty sand to sandy silt
13.123	70.00	1.0836	1.548	6.140	22	7	silty sand to sandy silt
13.287	89.97	1.1476	1.275	4.786	22	8	sand to silty sand
13.451	90.72	1.0689	1.178	4.755	22	8	sand to silty sand
13.615	78.07	0.9625	1.233	4.697	25	7	silty sand to sandy silt
13.780	66.87	0.9729	1.455	4.688	21	7	silty sand to sandy silt
13.944	67.82	1.0318	1.521	4.643	22	7	silty sand to sandy silt
14.108	71.98	0.4488	0.623	4.607	17	8	sand to silty sand
14.272	69.69	0.6080	0.872	4.562	17	8	sand to silty sand
14.436	62.63	0.7284	1.163	1.701	20	7	silty sand to sandy silt
14.600	58.40	0.7306	1.251	1.668	19	7	silty sand to sandy silt
14.764	56.58	0.7194	1.271	1.668	18	7	silty sand to sandy silt
14.928	56.07	0.7429	1.325	1.637	18	7	silty sand to sandy silt
15.092	55.13	0.8196	1.487	1.651	18	7	silty sand to sandy silt
15.256	56.59	0.8784	1.552	1.668	18	7	silty sand to sandy silt
15.420	58.43	0.9489	1.624	1.659	19	7	silty sand to sandy silt
15.584	48.73	0.8879	1.822	1.680	16	7	silty sand to sandy silt
15.748	46.15	1.0509	2.277	1.651	18	6	sandy silt to clayey silt
15.912	59.83	1.2075	2.018	2.016	19	7	silty sand to sandy silt
16.076	64.86	1.2332	1.901	1.932	21	7	silty sand to sandy silt
16.240	65.96	1.2263	1.859	1.866	21	7	silty sand to sandy silt
16.404	60.57	1.2660	2.090	1.823	19	7	silty sand to sandy silt
16.568	66.03	1.2388	1.876	1.842	21	7	silty sand to sandy silt
16.732	70.80	1.1196	1.581	1.828	23	7	silty sand to sandy silt
16.896	73.53	1.0130	1.378	1.823	23	7	silty sand to sandy silt
17.060	77.53	1.0689	1.379	1.820	25	7	silty sand to sandy silt
17.224	75.28	1.0639	1.413	1.839	24	7	silty sand to sandy silt
17.388	74.42	1.0172	1.367	1.839	24	7	silty sand to sandy silt
17.552	71.09	0.9063	1.275	1.835	23	7	silty sand to sandy silt
17.717	61.80	0.8557	1.385	1.804	20	7	silty sand to sandy silt
17.881	58.32	0.9270	1.589	1.778	19	7	silty sand to sandy silt
18.045	68.61	0.9930	1.447	1.792	22	7	silty sand to sandy silt
18.209	76.22	1.0252	1.345	1.828	24	7	silty sand to sandy silt
18.373	79.71	0.9995	1.254	1.820	25	7	silty sand to sandy silt
18.537	84.56	1.0389	1.229	1.856	20	8	sand to silty sand
18.701	88.90	1.1469	1.290	1.859	21	8	sand to silty sand
18.865	99.11	1.2289	1.240	1.849	24	8	sand to silty sand
19.029	113.32	1.2190	1.076	1.923	27	8	sand to silty sand
19.193	115.91	1.1432	0.986	1.920	28	8	sand to silty sand
19.357	94.75	1.2389	1.308	1.911	23	8	sand to silty sand
19.521	92.56	1.2308	1.330	1.880	22	8	sand to silty sand
19.685	92.27	1.3943	1.511	1.928	29	7	silty sand to sandy silt
19.849	87.63	1.3732	1.567	1.573	28	7	silty sand to sandy silt
20.013	86.73	1.1964	1.379	1.602	28	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
20.177	81.31	1.2793	1.573	1.625	26	7	silty sand to sandy silt
20.341	78.28	1.2884	1.646	1.585	25	7	silty sand to sandy silt
20.505	90.07	1.3540	1.503	1.661	29	7	silty sand to sandy silt
20.669	88.06	1.4307	1.625	1.656	28	7	silty sand to sandy silt
20.833	84.33	1.5415	1.828	1.649	27	7	silty sand to sandy silt
20.997	72.82	1.8525	2.544	1.723	28	6	sandy silt to clayey silt
21.161	43.32	1.5110	3.488	1.775	21	5	clayey silt to silty clay
21.325	35.86	1.2215	3.406	2.006	17	5	clayey silt to silty clay
21.490	48.94	1.2882	2.632	2.213	19	6	sandy silt to clayey silt
21.654	36.54	0.9425	2.579	2.161	14	6	sandy silt to clayey silt
21.818	20.50	0.6842	3.338	2.446	10	5	clayey silt to silty clay
21.982	16.10	0.4109	2.553	2.770	8	5	clayey silt to silty clay
22.146	16.52	0.4227	2.559	3.010	8	5	clayey silt to silty clay
22.310	17.45	0.6979	3.999	3.189	11	4	silty clay to clay
22.474	22.86	1.1388	4.982	3.819	22	3	clay
22.638	35.52	1.3075	3.681	4.024	17	5	clayey silt to silty clay
22.802	81.53	1.5816	1.940	4.324	26	7	silty sand to sandy silt
22.966	112.69	1.8194	1.615	4.076	36	7	silty sand to sandy silt
23.130	126.65	1.9531	1.542	3.943	30	8	sand to silty sand
23.294	150.16	1.9386	1.291	4.098	36	8	sand to silty sand
23.458	164.79	1.6710	1.014	4.195	32	9	sand
23.622	173.78	1.8296	1.053	4.255	33	9	sand
23.786	184.76	1.8365	0.994	4.276	35	9	sand
23.950	185.78	1.4882	0.801	4.479	36	9	sand
24.114	163.97	1.1906	0.726	4.483	31	9	sand
24.278	158.77	1.3132	0.827	4.469	30	9	sand
24.442	130.93	1.4318	1.094	4.519	31	8	sand to silty sand
24.606	129.56	1.6023	1.237	4.564	31	8	sand to silty sand
24.770	152.60	1.6132	1.057	4.498	37	8	sand to silty sand
24.934	144.88	1.5060	1.040	4.521	35	8	sand to silty sand
25.098	134.02	1.3685	1.021	4.505	32	8	sand to silty sand
25.262	140.21	1.5336	1.094	4.598	34	8	sand to silty sand
25.427	155.36	1.7717	1.140	4.683	37	8	sand to silty sand
25.591	161.72	2.0800	1.286	4.766	39	8	sand to silty sand
25.755	162.51	2.4513	1.508	4.467	39	8	sand to silty sand
25.919	171.95	2.8698	1.669	4.469	41	8	sand to silty sand
26.083	188.90	2.6873	1.423	4.640	45	8	sand to silty sand
26.247	204.08	2.6681	1.307	4.614	49	8	sand to silty sand
26.411	196.89	2.7864	1.415	3.922	47	8	sand to silty sand
26.575	186.42	2.8763	1.543	3.972	45	8	sand to silty sand
26.739	173.74	2.7014	1.555	3.957	42	8	sand to silty sand
26.903	142.44	2.2375	1.571	3.948	34	8	sand to silty sand
27.067	107.98	2.0284	1.878	3.915	34	7	silty sand to sandy silt
27.231	86.12	2.1375	2.482	3.881	33	6	sandy silt to clayey silt
27.395	85.57	2.2938	2.681	3.903	33	6	sandy silt to clayey silt
27.559	127.99	2.6143	2.043	4.100	41	7	silty sand to sandy silt
27.723	190.23	2.6964	1.417	4.100	46	8	sand to silty sand
27.887	211.36	2.6836	1.270	4.103	40	9	sand
28.051	191.95	2.2747	1.185	4.093	37	9	sand
28.215	143.48	1.8602	1.296	4.105	34	8	sand to silty sand
28.379	124.37	1.5424	1.240	3.953	30	8	sand to silty sand
28.543	103.93	1.7365	1.671	3.995	33	7	silty sand to sandy silt
28.707	88.61	2.0531	2.317	4.088	28	7	silty sand to sandy silt
28.871	49.12	2.0163	4.104	4.007	24	5	clayey silt to silty clay
29.035	41.23	2.1559	5.229	3.817	39	3	clay
29.199	40.04	1.9911	4.972	4.612	38	3	clay
29.364	102.27	1.8146	1.774	5.423	33	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
29.528	116.48	1.5012	1.289	4.912	28	8	sand to silty sand
29.692	122.46	1.4279	1.166	4.678	29	8	sand to silty sand
29.856	134.52	1.7973	1.336	4.588	32	8	sand to silty sand
30.020	126.49	1.8593	1.470	4.671	30	8	sand to silty sand
30.184	99.14	2.1119	2.130	4.538	32	7	silty sand to sandy silt
30.348	48.35	1.6779	3.471	4.357	23	5	clayey silt to silty clay
30.512	24.88	1.3220	5.314	4.526	24	3	clay
30.676	30.12	1.5711	5.216	5.297	29	3	clay
30.840	60.59	2.0445	3.374	7.351	29	5	clayey silt to silty clay
31.004	92.24	2.1979	2.383	6.858	29	7	silty sand to sandy silt
31.168	101.02	2.2715	2.249	6.663	32	7	silty sand to sandy silt
31.332	94.91	2.4960	2.630	6.413	36	6	sandy silt to clayey silt
31.496	100.20	3.0271	3.021	6.270	38	6	sandy silt to clayey silt
31.660	117.46	3.3926	2.888	6.270	45	6	sandy silt to clayey silt
31.824	136.12	3.6865	2.708	6.261	43	7	silty sand to sandy silt
31.988	138.55	3.0271	2.185	6.199	44	7	silty sand to sandy silt
32.152	126.57	2.5580	2.021	6.190	40	7	silty sand to sandy silt
32.316	159.79	2.2354	1.399	5.940	38	8	sand to silty sand
32.480	174.36	1.9571	1.122	5.780	42	8	sand to silty sand
32.644	163.83	1.4050	0.858	5.825	31	9	sand
32.808	143.99	1.4467	1.005	5.664	34	8	sand to silty sand
32.972	150.93	1.5756	1.044	3.710	36	8	sand to silty sand
33.136	155.11	1.4969	0.965	3.865	30	9	sand
33.301	151.51	1.2686	0.837	3.836	29	9	sand
33.465	132.34	1.1276	0.852	3.850	32	8	sand to silty sand
33.629	114.57	1.4250	1.244	3.827	27	8	sand to silty sand
33.793	111.16	1.8850	1.696	3.853	35	7	silty sand to sandy silt
33.957	116.68	2.4214	2.075	3.879	37	7	silty sand to sandy silt
34.121	126.57	2.5562	2.020	3.912	40	7	silty sand to sandy silt
34.285	135.40	2.2996	1.698	3.824	32	8	sand to silty sand
34.449	136.65	2.0185	1.477	3.731	33	8	sand to silty sand
34.613	144.57	1.7343	1.200	3.655	35	8	sand to silty sand
34.777	152.41	1.3679	0.898	3.689	29	9	sand
34.941	142.30	0.9956	0.700	3.643	27	9	sand
35.105	125.38	0.8767	0.699	3.555	24	9	sand
35.269	129.63	1.3050	1.007	3.431	31	8	sand to silty sand
35.433	165.46	2.2027	1.331	3.051	40	8	sand to silty sand
35.597	173.78	1.9520	1.123	3.367	42	8	sand to silty sand
35.761	199.04	2.1467	1.079	3.434	38	9	sand
35.925	159.27	1.9126	1.201	3.565	38	8	sand to silty sand
36.089	156.25	1.3436	0.860	3.946	30	9	sand
36.253	137.34	1.0697	0.779	4.233	26	9	sand
36.417	126.89	1.1353	0.895	4.181	30	8	sand to silty sand
36.581	120.70	1.4413	1.194	4.179	29	8	sand to silty sand
36.745	106.64	1.7221	1.615	4.319	34	7	silty sand to sandy silt
36.909	89.69	1.7762	1.980	4.548	29	7	silty sand to sandy silt
37.073	100.63	1.7817	1.771	4.509	32	7	silty sand to sandy silt
37.238	124.96	1.7947	1.436	4.450	30	8	sand to silty sand
37.402	133.83	1.9373	1.448	4.379	32	8	sand to silty sand
37.566	117.82	2.0252	1.719	4.310	38	7	silty sand to sandy silt
37.730	116.68	2.4884	2.133	4.267	37	7	silty sand to sandy silt
37.894	123.80	2.9605	2.391	4.212	40	7	silty sand to sandy silt
38.058	119.27	3.6267	3.041	4.279	46	6	sandy silt to clayey silt
38.222	109.37	3.5844	3.277	4.257	42	6	sandy silt to clayey silt
38.386	125.84	3.5571	2.827	4.747	48	6	sandy silt to clayey silt
38.550	119.38	2.6200	2.195	4.436	38	7	silty sand to sandy silt
38.714	107.65	2.9959	2.783	4.345	41	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
38.878	135.64	3.5429	2.612	3.786	43	7	silty sand to sandy silt
39.042	142.79	3.6363	2.547	3.767	46	7	silty sand to sandy silt
39.206	139.50	2.7301	1.957	3.793	45	7	silty sand to sandy silt
39.370	128.02	2.1666	1.692	3.722	41	7	silty sand to sandy silt
39.534	100.33	1.7241	1.718	3.110	32	7	silty sand to sandy silt
39.698	93.97	1.6136	1.717	3.125	30	7	silty sand to sandy silt
39.862	92.83	1.6278	1.754	3.103	30	7	silty sand to sandy silt
40.026	97.85	1.7894	1.829	3.094	31	7	silty sand to sandy silt
40.190	106.21	1.9574	1.843	3.067	34	7	silty sand to sandy silt
40.354	110.67	2.0682	1.869	3.077	35	7	silty sand to sandy silt
40.518	120.56	2.1266	1.764	3.084	38	7	silty sand to sandy silt
40.682	137.47	2.2930	1.668	3.098	33	8	sand to silty sand
40.846	138.54	2.3580	1.702	3.134	33	8	sand to silty sand
41.011	120.30	2.2709	1.888	3.158	38	7	silty sand to sandy silt
41.175	103.28	2.4934	2.414	3.174	33	7	silty sand to sandy silt
41.339	89.00	3.2817	3.687	3.198	43	5	clayey silt to silty clay
41.503	84.22	3.4257	4.068	3.439	40	5	clayey silt to silty clay
41.667	128.26	3.9258	3.061	4.181	49	6	sandy silt to clayey silt
41.831	157.28	3.7041	2.355	3.879	50	7	silty sand to sandy silt
41.995	173.31	3.6680	2.116	3.876	55	7	silty sand to sandy silt
42.159	182.00	3.6592	2.011	3.712	58	7	silty sand to sandy silt
42.323	181.50	3.4213	1.885	3.674	43	8	sand to silty sand
42.487	186.43	3.1348	1.681	3.686	45	8	sand to silty sand
42.651	200.88	3.0882	1.537	3.622	48	8	sand to silty sand
42.815	172.20	3.1706	1.841	3.762	41	8	sand to silty sand
42.979	119.32	3.5013	2.934	3.876	46	6	sandy silt to clayey silt
43.143	95.06	4.0250	4.234	4.012	46	5	clayey silt to silty clay
43.307	52.39	4.3554	8.314	4.588	50	3	clay
43.471	55.62	4.4066	7.922	4.793	53	3	clay
43.635	100.36	5.3548	5.336	5.164	96	11	very stiff fine grained (*)
43.799	100.68	5.4909	5.454	5.007	96	11	very stiff fine grained (*)
43.963	87.98	5.0982	5.795	5.259	84	11	very stiff fine grained (*)
44.127	94.47	3.9231	4.153	5.442	45	5	clayey silt to silty clay
44.291	101.71	2.7937	2.747	5.116	39	6	sandy silt to clayey silt
44.455	103.71	2.2729	2.192	4.957	33	7	silty sand to sandy silt
44.619	100.29	1.8628	1.857	4.888	32	7	silty sand to sandy silt
44.783	88.30	1.2398	1.404	4.797	28	7	silty sand to sandy silt
44.948	81.02	1.4597	1.802	4.576	26	7	silty sand to sandy silt
45.112	80.25	1.6519	2.058	4.483	26	7	silty sand to sandy silt
45.276	82.44	2.8318	3.435	4.452	32	6	sandy silt to clayey silt
45.440	47.16	2.1278	4.512	3.327	30	4	silty clay to clay
45.604	24.66	1.6537	6.706	3.936	24	3	clay
45.768	27.51	1.6934	6.156	4.778	26	3	clay
45.932	29.32	2.6909	9.177	5.133	28	3	clay
46.096	59.87	3.8962	6.507	6.737	57	11	very stiff fine grained (*)
46.260	70.91	4.3958	6.199	6.328	68	11	very stiff fine grained (*)
46.424	77.35	4.1639	5.384	6.197	74	11	very stiff fine grained (*)
46.588	78.58	3.9178	4.986	5.664	75	11	very stiff fine grained (*)
46.752	84.04	3.6776	4.376	5.357	40	5	clayey silt to silty clay
46.916	74.60	3.3479	4.488	5.073	36	5	clayey silt to silty clay
47.080	41.69	2.3429	5.620	5.000	40	3	clay
47.244	22.80	1.3378	5.868	5.711	22	3	clay
47.408	21.81	1.1925	5.468	5.961	21	3	clay
47.572	21.93	1.2146	5.539	6.128	21	3	clay
47.736	22.59	1.2500	5.534	6.249	22	3	clay
47.900	24.52	1.2860	5.246	6.385	23	3	clay
48.064	25.80	1.2930	5.012	6.451	25	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
48.228	27.07	1.0734	3.965	6.646	17	4	silty clay to clay
48.392	29.27	1.1949	4.082	6.887	19	4	silty clay to clay
48.556	36.08	1.3392	3.712	8.129	17	5	clayey silt to silty clay
48.720	35.74	1.4146	3.958	8.315	17	5	clayey silt to silty clay
48.885	34.24	1.3762	4.019	8.438	22	4	silty clay to clay
49.049	32.79	1.3246	4.040	8.567	21	4	silty clay to clay
49.213	32.11	1.2471	3.884	8.676	15	5	clayey silt to silty clay
49.377	34.49	1.1328	3.285	8.943	17	5	clayey silt to silty clay
49.541	33.70	1.0584	3.140	9.169	16	5	clayey silt to silty clay
49.705	31.96	0.9450	2.957	9.526	15	5	clayey silt to silty clay
49.869	32.59	0.9602	2.947	9.676	16	5	clayey silt to silty clay
50.033	32.17	0.9953	3.094	9.761	15	5	clayey silt to silty clay
50.197	30.75	0.9721	3.161	9.830	15	5	clayey silt to silty clay
50.361	31.01	0.9992	3.223	9.935	15	5	clayey silt to silty clay
50.525	32.51	1.1487	3.534	10.016	16	5	clayey silt to silty clay
50.689	31.58	1.2895	4.083	9.971	20	4	silty clay to clay
50.853	30.54	1.2357	4.046	10.040	19	4	silty clay to clay
51.017	30.67	1.2281	4.004	10.152	20	4	silty clay to clay
51.181	31.65	1.3985	4.418	10.216	20	4	silty clay to clay
51.345	32.62	1.5674	4.805	10.278	31	3	clay
51.509	32.17	1.6275	5.059	10.294	31	3	clay
51.673	32.20	1.4124	4.387	10.423	21	4	silty clay to clay
51.837	31.17	1.4263	4.575	10.478	20	4	silty clay to clay
52.001	30.97	1.5215	4.913	11.403	30	3	clay
52.165	31.39	1.4972	4.770	11.458	30	3	clay
52.329	31.96	1.6259	5.087	11.620	31	3	clay
52.493	31.36	1.5802	5.038	11.846	30	3	clay
52.657	31.27	1.5495	4.956	12.900	30	3	clay
52.822	31.41	1.4913	4.748	13.069	30	3	clay
52.986	31.69	1.4988	4.729	13.298	30	3	clay
53.150	31.93	1.6067	5.032	13.414	31	3	clay
53.314	32.00	1.7226	5.383	13.540	31	3	clay
53.478	31.31	1.7216	5.499	13.671	30	3	clay
53.642	30.57	1.6917	5.534	13.738	29	3	clay
53.806	31.51	1.6838	5.343	13.781	30	3	clay
53.970	32.11	1.7195	5.356	13.876	31	3	clay
54.134	32.17	1.7692	5.499	14.111	31	3	clay
54.298	32.88	1.7685	5.379	14.195	31	3	clay
54.462	32.85	1.8194	5.539	14.309	31	3	clay
54.626	31.52	1.8197	5.772	14.452	30	3	clay
54.790	30.81	1.5432	5.009	14.483	30	3	clay
54.954	30.25	1.5785	5.217	14.616	29	3	clay
55.118	28.65	1.6271	5.679	14.711	27	3	clay
55.282	29.89	1.5941	5.333	14.942	29	3	clay
55.446	28.53	1.6130	5.653	14.975	27	3	clay
55.610	28.29	1.5548	5.497	15.073	27	3	clay
55.774	27.31	1.5276	5.594	14.994	26	3	clay
55.938	25.38	1.4544	5.731	15.009	24	3	clay
56.102	25.28	1.3864	5.485	15.028	24	3	clay
56.266	24.84	1.3532	5.448	15.023	24	3	clay
56.430	23.80	1.3398	5.629	14.952	23	3	clay
56.594	22.64	1.1629	5.137	14.790	22	3	clay
56.759	21.81	1.0936	5.014	14.842	21	3	clay
56.923	22.93	1.2082	5.269	14.854	22	3	clay
57.087	24.28	1.2670	5.219	14.930	23	3	clay
57.251	24.29	1.2816	5.276	15.094	23	3	clay
57.415	24.14	1.1328	4.693	15.113	23	3	clay

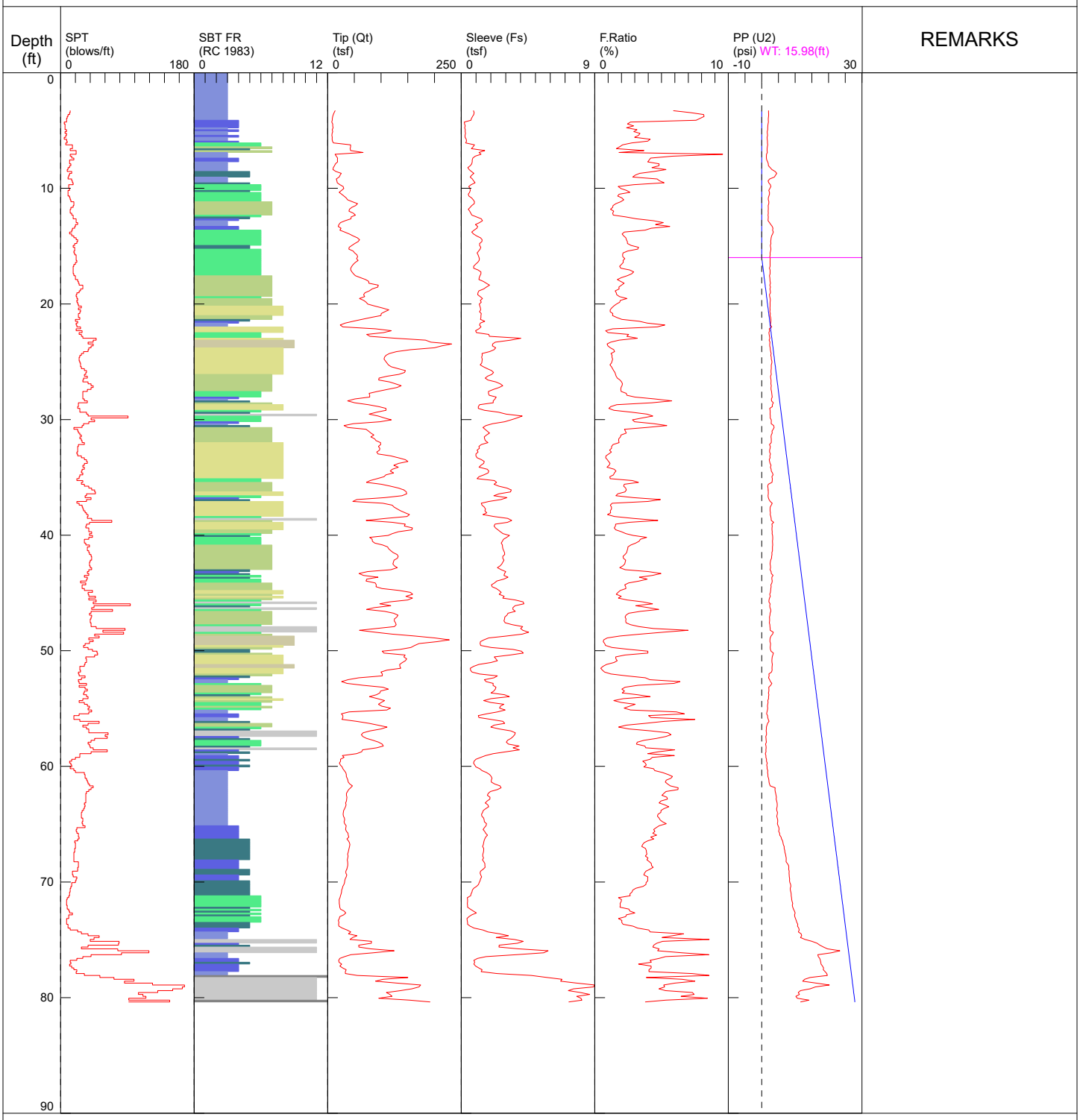
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
57.579	23.36	0.9961	4.264	15.268	15	4	silty clay to clay
57.743	23.30	1.0189	4.372	15.556	22	3	clay
57.907	23.12	1.0996	4.755	15.437	22	3	clay
58.071	21.99	0.8647	3.932	15.477	14	4	silty clay to clay
58.235	20.48	0.8727	4.261	15.439	20	3	clay
58.399	20.07	0.9492	4.731	15.416	19	3	clay
58.563	21.35	0.9483	4.441	15.506	20	3	clay
58.727	21.56	0.8721	4.045	15.558	14	4	silty clay to clay
58.891	21.20	0.7093	3.347	15.761	10	5	clayey silt to silty clay
59.055	21.28	0.7025	3.301	15.903	10	5	clayey silt to silty clay
59.219	23.15	0.6944	2.999	17.326	11	5	clayey silt to silty clay
59.383	23.65	0.7151	3.023	17.600	11	5	clayey silt to silty clay
59.547	24.75	0.7303	2.951	17.898	12	5	clayey silt to silty clay
59.711	25.91	0.7089	2.736	18.128	12	5	clayey silt to silty clay
59.875	26.20	0.6985	2.666	18.343	13	5	clayey silt to silty clay
60.039	27.74	0.6908	2.490	18.521	11	6	sandy silt to clayey silt
60.203	29.11	0.7157	2.458	18.976	11	6	sandy silt to clayey silt
60.367	28.96	0.7347	2.537	19.306	11	6	sandy silt to clayey silt
60.532	27.81	0.7211	2.593	19.444	11	6	sandy silt to clayey silt
60.696	27.68	0.6929	2.503	19.797	11	6	sandy silt to clayey silt
60.860	27.59	0.6674	2.419	19.851	11	6	sandy silt to clayey silt
61.024	27.69	0.6455	2.331	20.044	11	6	sandy silt to clayey silt
61.188	28.21	0.6616	2.346	20.173	11	6	sandy silt to clayey silt
61.352	30.36	0.7092	2.336	20.499	12	6	sandy silt to clayey silt
61.516	31.98	0.7733	2.418	21.170	12	6	sandy silt to clayey silt
61.680	33.59	0.8617	2.565	21.684	13	6	sandy silt to clayey silt
61.844	32.26	0.9057	2.807	22.921	12	6	sandy silt to clayey silt
62.008	29.96	0.8252	2.754	23.111	14	5	clayey silt to silty clay
62.172	30.28	0.7136	2.357	23.754	12	6	sandy silt to clayey silt
62.336	29.30	0.6907	2.357	23.985	11	6	sandy silt to clayey silt
62.500	31.73	0.9083	2.863	24.499	15	5	clayey silt to silty clay
62.664	51.81	1.5341	2.961	25.339	20	6	sandy silt to clayey silt
62.828	53.29	2.0207	3.792	24.694	26	5	clayey silt to silty clay
62.992	48.61	2.2048	4.536	28.363	31	4	silty clay to clay
63.156	48.78	1.8382	3.768	27.628	23	5	clayey silt to silty clay
63.320	34.70	1.5297	4.408	28.406	22	4	silty clay to clay
63.484	36.69	1.1168	3.044	28.701	18	5	clayey silt to silty clay
63.648	31.95	1.2530	3.922	28.925	20	4	silty clay to clay
63.812	42.79	1.6733	3.911	29.974	20	5	clayey silt to silty clay
63.976	61.79	2.2260	3.602	30.629	30	5	clayey silt to silty clay
64.140	62.99	2.6084	4.141	31.295	30	5	clayey silt to silty clay
64.304	74.66	3.4920	4.677	32.987	71	11	very stiff fine grained (*)
64.469	75.10	3.5769	4.763	26.790	72	11	very stiff fine grained (*)
64.633	76.95	3.2429	4.214	31.402	37	5	clayey silt to silty clay
64.797	55.08	3.5177	6.387	29.073	53	3	clay
64.961	64.42	3.6949	5.736	35.526	62	11	very stiff fine grained (*)
65.125	74.74	3.6697	4.910	33.675	72	11	very stiff fine grained (*)
65.289	71.61	3.2918	4.597	39.103	46	4	silty clay to clay
65.453	76.95	5.0739	6.594	40.833	74	11	very stiff fine grained (*)
65.617	79.33	4.3619	5.499	43.103	76	11	very stiff fine grained (*)
65.781	74.98	3.7410	4.989	32.692	72	11	very stiff fine grained (*)
65.945	82.28	3.3387	4.058	37.718	39	5	clayey silt to silty clay
66.109	93.32	3.9109	4.191	42.282	45	5	clayey silt to silty clay
66.273	77.55	3.6957	4.765	39.981	74	11	very stiff fine grained (*)
66.437	73.67	3.2852	4.459	41.454	35	5	clayey silt to silty clay
66.601	65.40	3.1051	4.748	44.762	42	4	silty clay to clay
66.765	69.02	2.7900	4.042	46.425	33	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
66.929	74.19	2.9611	3.991	48.557	36	5	clayey silt to silty clay
67.093	74.65	3.0021	4.022	48.862	36	5	clayey silt to silty clay
67.257	88.14	3.3869	3.843	58.224	42	5	clayey silt to silty clay
67.421	98.44	3.9281	3.990	50.861	47	5	clayey silt to silty clay
67.585	63.66	3.6170	5.682	41.868	61	11	very stiff fine grained (*)
67.749	63.30	2.9179	4.610	41.295	40	4	silty clay to clay
67.913	59.47	2.4881	4.184	45.645	28	5	clayey silt to silty clay
68.077	69.48	3.5988	5.180	48.731	67	11	very stiff fine grained (*)
68.241	68.19	3.1782	4.661	47.460	44	4	silty clay to clay
68.406	63.90	2.9885	4.677	47.724	41	4	silty clay to clay
68.570	52.57	2.5097	4.774	45.944	34	4	silty clay to clay
68.734	39.69	2.0944	5.277	46.815	38	3	clay
68.898	36.19	1.4302	3.952	47.977	17	5	clayey silt to silty clay
69.062	37.41	1.3967	3.734	48.227	18	5	clayey silt to silty clay
69.226	35.60	1.2332	3.464	47.282	17	5	clayey silt to silty clay
69.390	34.06	1.1060	3.247	48.086	16	5	clayey silt to silty clay
69.554	37.35	1.0862	2.908	48.629	14	6	sandy silt to clayey silt
69.718	38.29	1.1139	2.909	49.833	15	6	sandy silt to clayey silt
69.882	42.79	1.2086	2.825	50.780	16	6	sandy silt to clayey silt
70.046	41.58	1.3140	3.160	51.572	20	5	clayey silt to silty clay
70.210	44.99	1.3299	2.956	52.879	17	6	sandy silt to clayey silt
70.374	44.93	1.4228	3.167	53.640	22	5	clayey silt to silty clay
70.538	51.09	1.4958	2.928	55.665	20	6	sandy silt to clayey silt
70.702	45.66	1.6179	3.544	56.720	22	5	clayey silt to silty clay
70.866	44.80	1.6785	3.746	57.081	21	5	clayey silt to silty clay
71.030	51.58	1.7312	3.356	57.541	25	5	clayey silt to silty clay
71.194	46.77	1.8652	3.988	55.934	22	5	clayey silt to silty clay
71.358	40.86	1.1473	2.808	54.140	16	6	sandy silt to clayey silt
71.522	39.09	0.9709	2.484	57.336	15	6	sandy silt to clayey silt
71.686	38.89	1.2550	3.227	62.252	19	5	clayey silt to silty clay
71.850	55.13	1.3742	2.493	70.734	21	6	sandy silt to clayey silt
72.014	49.36	2.5137	5.093	65.651	47	3	clay
72.178	46.07	2.0094	4.361	70.529	29	4	silty clay to clay
72.343	47.98	1.4038	2.926	90.868	18	6	sandy silt to clayey silt
72.507	44.58	1.0997	2.467	97.588	17	6	sandy silt to clayey silt
72.671	43.28	0.9625	2.224	103.954	17	6	sandy silt to clayey silt
72.835	42.72	0.9269	2.170	108.235	16	6	sandy silt to clayey silt
72.999	41.86	0.9944	2.376	111.681	16	6	sandy silt to clayey silt
73.163	49.78	1.1251	2.260	116.442	19	6	sandy silt to clayey silt
73.327	50.15	1.2665	2.526	114.689	19	6	sandy silt to clayey silt
73.491	50.43	1.3381	2.654	123.182	19	6	sandy silt to clayey silt
73.655	50.95	1.2665	2.486	123.415	20	6	sandy silt to clayey silt
73.819	49.99	1.1600	2.320	129.262	19	6	sandy silt to clayey silt
73.983	45.12	1.0974	2.432	129.440	17	6	sandy silt to clayey silt
74.147	44.36	1.5161	3.418	131.113	21	5	clayey silt to silty clay
74.311	58.57	1.7311	2.956	126.911	22	6	sandy silt to clayey silt
74.475	47.74	1.8673	3.911	128.155	23	5	clayey silt to silty clay
74.639	45.77	2.0871	4.559	142.098	29	4	silty clay to clay
74.803	45.02	1.9925	4.426	143.830	29	4	silty clay to clay
74.967	43.20	1.7967	4.159	149.874	28	4	silty clay to clay
75.131	44.57	1.5577	3.495	165.911	21	5	clayey silt to silty clay
75.295	44.24	1.3669	3.090	166.727	21	5	clayey silt to silty clay
75.459	46.70	1.4267	3.055	171.898	18	6	sandy silt to clayey silt
75.623	50.51	1.3962	2.764	181.679	19	6	sandy silt to clayey silt
75.787	48.46	1.3856	2.859	186.705	19	6	sandy silt to clayey silt
75.951	45.64	1.3213	2.895	192.513	17	6	sandy silt to clayey silt
76.115	43.46	1.2515	2.880	196.254	17	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
76.280	42.90	1.2415	2.894	197.794	16	6	sandy silt to clayey silt
76.444	43.42	1.2072	2.780	202.294	17	6	sandy silt to clayey silt
76.608	45.76	1.2032	2.629	208.065	18	6	sandy silt to clayey silt
76.772	45.17	1.2741	2.820	216.160	17	6	sandy silt to clayey silt
76.936	44.34	1.2854	2.899	212.912	17	6	sandy silt to clayey silt
77.100	46.50	1.2626	2.715	217.105	18	6	sandy silt to clayey silt
77.264	47.46	1.2595	2.654	218.571	18	6	sandy silt to clayey silt
77.428	45.62	1.2522	2.745	231.833	17	6	sandy silt to clayey silt
77.592	46.98	1.2522	2.666	230.755	18	6	sandy silt to clayey silt
77.756	46.87	1.3313	2.840	237.289	18	6	sandy silt to clayey silt
77.920	46.31	1.3534	2.923	229.006	18	6	sandy silt to clayey silt
78.084	44.17	1.3034	2.951	238.610	17	6	sandy silt to clayey silt
78.248	44.53	1.2668	2.845	239.650	17	6	sandy silt to clayey silt
78.412	44.14	1.1471	2.599	242.342	17	6	sandy silt to clayey silt
78.576	42.57	1.3556	3.184	253.198	20	5	clayey silt to silty clay
78.740	42.90	1.2776	2.978	255.070	16	6	sandy silt to clayey silt
78.904	43.90	1.0475	2.386	286.242	17	6	sandy silt to clayey silt
79.068	44.02	1.0196	2.316	292.993	17	6	sandy silt to clayey silt
79.232	44.89	1.0794	2.405	301.350	17	6	sandy silt to clayey silt
79.396	46.65	1.0979	2.353	304.858	18	6	sandy silt to clayey silt
79.560	47.12	1.1700	2.483	316.459	18	6	sandy silt to clayey silt
79.724	47.78	1.1887	2.488	306.709	18	6	sandy silt to clayey silt
79.888	46.43	1.1726	2.526	299.506	18	6	sandy silt to clayey silt
80.052	46.47	1.1768	2.532	305.917	18	6	sandy silt to clayey silt
80.217	46.85	1.1070	2.363	312.114	18	6	sandy silt to clayey silt
80.381	47.64	1.1104	2.331	313.063	18	6	sandy silt to clayey silt
80.545	47.89	1.1367	2.373	315.807	18	6	sandy silt to clayey silt
80.709	47.74	1.1620	2.434	311.512	18	6	sandy silt to clayey silt
80.873	48.31	1.1353	2.350	317.425	19	6	sandy silt to clayey silt
81.037	49.55	1.3363	2.697	317.856	19	6	sandy silt to clayey silt
81.201	49.69	1.3452	2.707	302.445	19	6	sandy silt to clayey silt
81.365	51.87	1.3792	2.659	314.876	20	6	sandy silt to clayey silt
81.529	52.86	1.3159	2.489	328.065	20	6	sandy silt to clayey silt
81.693	52.72	1.3288	2.521	341.331	20	6	sandy silt to clayey silt
81.857	54.01	1.2533	2.321	350.543	21	6	sandy silt to clayey silt
82.021	53.78	1.3129	2.441	341.105	21	6	sandy silt to clayey silt
82.185	50.78	1.2748	2.510	299.873	19	6	sandy silt to clayey silt
82.349	50.41	1.2597	2.499	314.020	19	6	sandy silt to clayey silt
82.513	51.09	1.1024	2.158	325.733	20	6	sandy silt to clayey silt
82.677	52.86	1.2155	2.300	340.044	20	6	sandy silt to clayey silt
82.841	58.69	1.4018	2.388	370.870	22	6	sandy silt to clayey silt
83.005	63.51	1.5889	2.502	394.120	24	6	sandy silt to clayey silt
83.169	65.95	1.7904	2.715	414.199	25	6	sandy silt to clayey silt
83.333	67.20	1.7989	2.677	428.002	26	6	sandy silt to clayey silt
83.497	66.99	1.8971	2.832	470.467	26	6	sandy silt to clayey silt
83.661	67.87	1.7299	2.549	441.835	26	6	sandy silt to clayey silt
83.825	73.87	2.0048	2.714	470.155	28	6	sandy silt to clayey silt
83.990	76.37	2.4062	3.151	335.882	29	6	sandy silt to clayey silt
84.154	73.49	2.5932	3.529	326.844	35	5	clayey silt to silty clay
84.318	77.93	5.3341	6.845	361.261	75	11	very stiff fine grained (*)
84.482	77.97	4.9294	6.322	337.305	75	11	very stiff fine grained (*)
84.646	85.91	4.0106	4.669	185.458	82	11	very stiff fine grained (*)
84.810	83.00	3.4786	4.191	232.064	40	5	clayey silt to silty clay
84.974	66.54	2.8847	4.335	231.333	32	5	clayey silt to silty clay
85.138	58.32	2.5307	4.339	218.212	28	5	clayey silt to silty clay
85.302	70.65	2.9008	4.106	249.980	34	5	clayey silt to silty clay

Jacobs / CPT C-02 / 16580 SW 85th Ave Tigard

OPERATOR: OGE BAK
CONE ID: DDG1415
TEST DATE: 8/14/2023 11:55:44 AM
TOTAL DEPTH: 80.381 ft

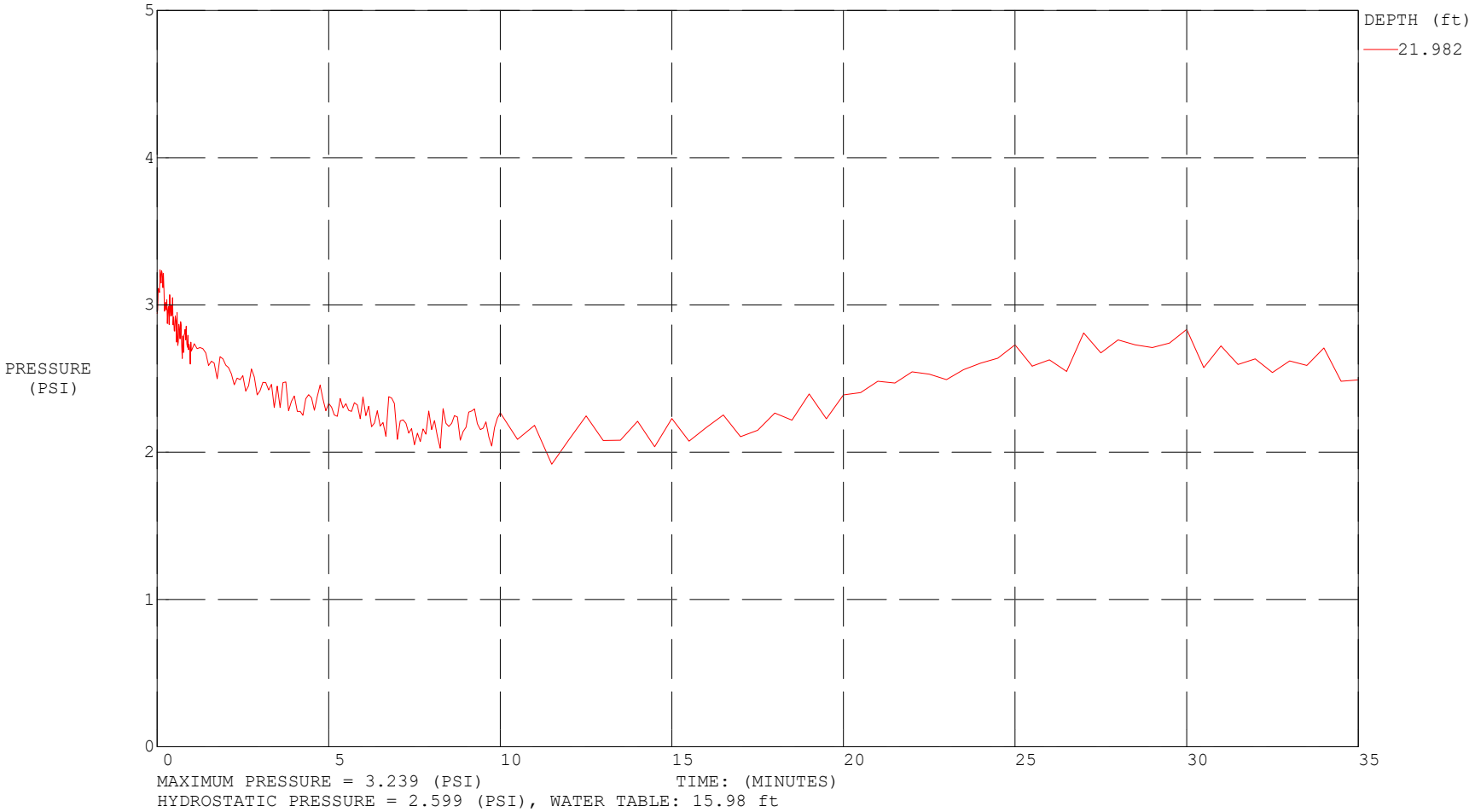


1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: Jacobs / CPT C-02 / 16580 SW 85th Ave Tigard

CONE ID: DDG1415
TEST DATE: 8/14/2023 11:55:44 AM



Jacobs / CPT C-02 / 16580 SW 85th Ave Tigard

OPERATOR: OGE BAK
CONE ID: DDG1415
TEST DATE: 8/14/2023 11:55:44 AM
TOTAL DEPTH: 80.381 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
3.281	14.03	0.8280	5.900	2.037	13	3	clay
3.445	12.10	0.8664	7.161	2.023	12	3	clay
3.609	10.39	0.8461	8.147	2.049	10	3	clay
3.773	9.37	0.7667	8.186	2.037	9	3	clay
3.937	8.80	0.6934	7.883	1.932	8	3	clay
4.101	8.54	0.6484	7.588	1.942	8	3	clay
4.265	7.65	0.2048	2.676	1.992	5	4	silty clay to clay
4.429	9.44	0.2307	2.444	1.887	6	4	silty clay to clay
4.593	9.29	0.2701	2.907	1.823	6	4	silty clay to clay
4.757	10.01	0.2376	2.374	1.799	6	4	silty clay to clay
4.921	8.60	0.2715	3.156	1.766	8	3	clay
5.085	9.23	0.2698	2.922	1.647	6	4	silty clay to clay
5.249	8.45	0.2866	3.391	1.663	8	3	clay
5.413	7.75	0.2541	3.278	1.723	7	3	clay
5.577	8.50	0.2537	2.987	1.582	5	4	silty clay to clay
5.741	8.13	0.3376	4.151	1.659	8	3	clay
5.906	8.94	0.3541	3.960	1.706	9	3	clay
6.070	10.73	0.2975	2.771	1.711	7	4	silty clay to clay
6.234	42.81	0.8901	2.079	1.766	16	6	sandy silt to clayey silt
6.398	43.01	0.8026	1.866	1.666	16	6	sandy silt to clayey silt
6.562	42.03	0.6805	1.619	1.575	13	7	silty sand to sandy silt
6.726	43.06	1.5834	3.677	1.604	21	5	clayey silt to silty clay
6.890	66.23	1.1977	1.808	1.668	21	7	silty sand to sandy silt
7.054	13.95	1.3356	9.572	1.421	13	3	clay
7.218	16.04	0.9356	5.833	1.390	15	3	clay
7.382	18.58	0.7766	4.181	1.387	18	3	clay
7.546	18.08	0.7364	4.073	1.497	12	4	silty clay to clay
7.710	18.59	0.7373	3.966	1.759	12	4	silty clay to clay
7.874	14.59	0.7031	4.820	1.939	14	3	clay
8.038	12.70	0.6099	4.800	1.989	12	3	clay
8.202	10.35	0.4435	4.284	2.553	10	3	clay
8.366	9.90	0.5279	5.330	3.025	9	3	clay
8.530	15.32	0.6808	4.444	3.998	15	3	clay
8.694	25.41	0.8529	3.356	4.509	12	5	clayey silt to silty clay
8.858	23.18	0.7007	3.022	4.143	11	5	clayey silt to silty clay
9.022	21.34	0.6052	2.836	3.781	10	5	clayey silt to silty clay
9.186	15.99	0.7455	4.664	2.399	15	3	clay
9.350	17.20	0.8361	4.862	1.878	16	3	clay
9.514	17.95	0.9315	5.189	2.106	17	3	clay
9.678	22.98	0.6705	2.918	2.582	11	5	clayey silt to silty clay
9.843	28.86	0.5039	1.746	2.746	11	6	sandy silt to clayey silt
10.007	30.15	0.5910	1.960	2.411	12	6	sandy silt to clayey silt
10.171	25.80	0.6126	2.374	2.077	10	6	sandy silt to clayey silt
10.335	21.41	0.5617	2.624	2.337	10	5	clayey silt to silty clay
10.499	26.26	0.4776	1.819	2.342	10	6	sandy silt to clayey silt
10.663	30.30	0.5179	1.709	2.149	12	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.827	34.58	0.6990	2.022	1.944	13	6	sandy silt to clayey silt
10.991	37.32	0.8096	2.169	1.978	14	6	sandy silt to clayey silt
11.155	46.20	0.8940	1.935	2.120	18	6	sandy silt to clayey silt
11.319	55.81	0.8790	1.575	2.085	18	7	silty sand to sandy silt
11.483	52.31	0.7116	1.360	1.920	17	7	silty sand to sandy silt
11.647	45.02	0.6032	1.340	1.930	14	7	silty sand to sandy silt
11.811	40.68	0.4778	1.175	1.987	13	7	silty sand to sandy silt
11.975	39.93	0.5688	1.425	1.920	13	7	silty sand to sandy silt
12.139	48.03	0.6449	1.343	1.978	15	7	silty sand to sandy silt
12.303	51.76	0.7184	1.388	1.894	17	7	silty sand to sandy silt
12.467	44.17	1.0234	2.317	1.963	17	6	sandy silt to clayey silt
12.631	43.55	1.3544	3.110	1.911	21	5	clayey silt to silty clay
12.795	32.61	1.4331	4.394	1.897	21	4	silty clay to clay
12.959	23.92	1.2251	5.122	2.320	23	3	clay
13.123	21.07	0.9587	4.551	2.722	20	3	clay
13.287	19.79	1.1131	5.624	3.148	19	3	clay
13.451	24.96	1.0539	4.223	3.351	16	4	silty clay to clay
13.615	22.93	0.8640	3.768	3.260	15	4	silty clay to clay
13.780	31.71	0.7021	2.214	3.467	12	6	sandy silt to clayey silt
13.944	40.41	0.8275	2.048	3.255	15	6	sandy silt to clayey silt
14.108	47.44	1.0249	2.161	2.967	18	6	sandy silt to clayey silt
14.272	55.55	1.2916	2.325	2.815	21	6	sandy silt to clayey silt
14.436	59.53	1.4079	2.365	2.739	23	6	sandy silt to clayey silt
14.600	56.88	1.3860	2.437	2.696	22	6	sandy silt to clayey silt
14.764	50.82	1.2428	2.445	2.756	19	6	sandy silt to clayey silt
14.928	45.47	1.2366	2.720	2.575	17	6	sandy silt to clayey silt
15.092	40.15	1.3169	3.280	2.696	19	5	clayey silt to silty clay
15.256	39.40	1.2672	3.216	2.734	19	5	clayey silt to silty clay
15.420	47.73	1.1749	2.462	2.630	18	6	sandy silt to clayey silt
15.584	50.40	1.0643	2.112	2.487	19	6	sandy silt to clayey silt
15.748	54.64	1.1351	2.078	2.534	21	6	sandy silt to clayey silt
15.912	56.06	1.1771	2.100	2.408	21	6	sandy silt to clayey silt
16.076	54.07	1.2177	2.252	2.541	21	6	sandy silt to clayey silt
16.240	56.89	1.2038	2.116	2.492	22	6	sandy silt to clayey silt
16.404	51.95	1.1101	2.137	2.475	20	6	sandy silt to clayey silt
16.568	47.86	0.9595	2.005	2.477	18	6	sandy silt to clayey silt
16.732	45.09	0.8345	1.851	2.496	17	6	sandy silt to clayey silt
16.896	43.17	0.8379	1.941	2.325	17	6	sandy silt to clayey silt
17.060	43.27	1.1325	2.617	2.513	17	6	sandy silt to clayey silt
17.224	45.48	1.3249	2.913	2.477	17	6	sandy silt to clayey silt
17.388	48.12	1.3299	2.764	2.489	18	6	sandy silt to clayey silt
17.552	51.74	1.2571	2.430	2.339	20	6	sandy silt to clayey silt
17.717	61.19	1.2160	1.987	2.427	20	7	silty sand to sandy silt
17.881	70.77	1.1888	1.680	2.451	23	7	silty sand to sandy silt
18.045	76.66	1.4804	1.931	2.472	24	7	silty sand to sandy silt
18.209	77.03	1.6909	2.195	2.589	25	7	silty sand to sandy silt
18.373	94.82	1.9021	2.006	2.427	30	7	silty sand to sandy silt
18.537	93.88	1.6922	1.803	2.594	30	7	silty sand to sandy silt
18.701	83.30	1.5127	1.816	2.451	27	7	silty sand to sandy silt
18.865	77.92	1.1896	1.527	2.568	25	7	silty sand to sandy silt
19.029	69.86	1.1246	1.610	2.587	22	7	silty sand to sandy silt
19.193	67.15	1.1062	1.647	2.330	21	7	silty sand to sandy silt
19.357	69.32	1.2796	1.846	2.394	22	7	silty sand to sandy silt
19.521	59.29	1.4252	2.404	2.532	23	6	sandy silt to clayey silt
19.685	67.57	1.2864	1.904	2.577	22	7	silty sand to sandy silt
19.849	72.06	1.3493	1.873	2.492	23	7	silty sand to sandy silt
20.013	75.01	1.2097	1.613	2.518	24	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
20.177	88.11	1.2538	1.423	2.482	28	7	silty sand to sandy silt
20.341	101.82	1.2906	1.268	2.439	24	8	sand to silty sand
20.505	114.52	1.3132	1.147	2.520	27	8	sand to silty sand
20.669	106.80	1.2271	1.149	2.406	26	8	sand to silty sand
20.833	100.32	1.3557	1.351	2.570	24	8	sand to silty sand
20.997	99.52	1.3285	1.335	2.508	24	8	sand to silty sand
21.161	80.85	1.3269	1.641	2.675	26	7	silty sand to sandy silt
21.325	63.93	1.2964	2.028	2.744	20	7	silty sand to sandy silt
21.490	47.37	1.5788	3.333	2.739	23	5	clayey silt to silty clay
21.654	32.70	1.2836	3.925	2.699	21	4	silty clay to clay
21.818	23.48	1.2309	5.243	2.611	22	3	clay
21.982	28.47	1.3303	4.673	2.977	27	3	clay
22.146	89.37	1.1949	1.337	2.256	21	8	sand to silty sand
22.310	119.09	0.9641	0.810	2.353	29	8	sand to silty sand
22.474	104.32	1.0350	0.992	2.135	25	8	sand to silty sand
22.638	73.11	1.8575	2.541	2.218	28	6	sandy silt to clayey silt
22.802	79.14	1.8965	2.396	2.320	30	6	sandy silt to clayey silt
22.966	126.03	4.0127	3.184	2.413	48	6	sandy silt to clayey silt
23.130	183.14	3.3263	1.816	2.213	44	8	sand to silty sand
23.294	193.31	2.2903	1.185	2.453	37	9	sand
23.458	231.88	2.1165	0.913	2.389	44	9	sand
23.622	213.58	2.1002	0.983	2.377	41	9	sand
23.786	199.73	2.3248	1.164	2.549	38	9	sand
23.950	155.14	2.2107	1.425	2.570	37	8	sand to silty sand
24.114	128.93	1.9143	1.485	2.689	31	8	sand to silty sand
24.278	115.51	1.3995	1.212	2.810	28	8	sand to silty sand
24.442	109.21	1.4147	1.295	2.710	26	8	sand to silty sand
24.606	106.38	1.3729	1.291	2.875	25	8	sand to silty sand
24.770	105.35	1.4140	1.342	2.844	25	8	sand to silty sand
24.934	108.13	1.4000	1.295	3.008	26	8	sand to silty sand
25.098	110.85	1.3829	1.248	3.015	27	8	sand to silty sand
25.262	113.63	1.2823	1.128	2.829	27	8	sand to silty sand
25.427	118.84	1.4867	1.251	2.851	28	8	sand to silty sand
25.591	131.85	1.7533	1.330	2.822	32	8	sand to silty sand
25.755	145.37	2.0407	1.404	2.789	35	8	sand to silty sand
25.919	143.86	2.1793	1.515	2.777	34	8	sand to silty sand
26.083	133.11	2.0570	1.545	2.865	32	8	sand to silty sand
26.247	111.71	1.7788	1.592	2.637	36	7	silty sand to sandy silt
26.411	96.02	1.6123	1.679	2.696	31	7	silty sand to sandy silt
26.575	95.43	1.7962	1.882	2.791	30	7	silty sand to sandy silt
26.739	115.53	2.3231	2.011	2.787	37	7	silty sand to sandy silt
26.903	126.94	2.6238	2.067	2.746	41	7	silty sand to sandy silt
27.067	137.51	2.7914	2.030	2.837	44	7	silty sand to sandy silt
27.231	129.48	2.5478	1.968	2.784	41	7	silty sand to sandy silt
27.395	111.67	2.1717	1.945	2.775	36	7	silty sand to sandy silt
27.559	93.05	1.8337	1.971	2.932	30	7	silty sand to sandy silt
27.723	77.39	1.8263	2.360	2.977	30	6	sandy silt to clayey silt
27.887	78.60	1.8827	2.395	3.072	30	6	sandy silt to clayey silt
28.051	78.48	2.3543	3.000	3.122	30	6	sandy silt to clayey silt
28.215	50.60	2.2730	4.492	2.887	32	4	silty clay to clay
28.379	37.37	2.1526	5.761	2.932	36	3	clay
28.543	50.46	2.1526	4.266	3.451	24	5	clayey silt to silty clay
28.707	76.01	1.2429	1.635	3.177	24	7	silty sand to sandy silt
28.871	95.60	1.1445	1.197	3.170	23	8	sand to silty sand
29.035	109.13	1.1460	1.050	2.382	26	8	sand to silty sand
29.199	109.31	1.5604	1.427	2.522	26	8	sand to silty sand
29.364	91.67	2.5202	2.749	2.549	35	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
29.528	77.53	3.0247	3.902	2.506	37	5	clayey silt to silty clay
29.692	94.60	4.1065	4.341	2.558	91	11	very stiff fine grained (*)
29.856	105.98	3.7694	3.557	2.532	41	6	sandy silt to clayey silt
30.020	119.19	3.3660	2.824	2.844	46	6	sandy silt to clayey silt
30.184	98.14	2.9253	2.981	2.822	38	6	sandy silt to clayey silt
30.348	48.17	2.1253	4.412	2.806	31	4	silty clay to clay
30.512	30.76	1.6604	5.397	3.558	29	3	clay
30.676	37.81	1.4627	3.868	3.708	18	5	clayey silt to silty clay
30.840	71.72	1.5983	2.229	3.443	23	7	silty sand to sandy silt
31.004	76.63	1.7573	2.293	3.075	24	7	silty sand to sandy silt
31.168	80.91	1.9019	2.351	3.141	26	7	silty sand to sandy silt
31.332	86.55	1.7001	1.964	2.834	28	7	silty sand to sandy silt
31.496	80.95	1.5533	1.919	2.777	26	7	silty sand to sandy silt
31.660	87.92	1.5771	1.794	2.877	28	7	silty sand to sandy silt
31.824	90.52	1.6198	1.789	2.877	29	7	silty sand to sandy silt
31.988	98.98	1.8006	1.819	2.822	32	7	silty sand to sandy silt
32.152	99.30	1.3511	1.361	2.327	24	8	sand to silty sand
32.316	94.95	1.1941	1.258	2.558	23	8	sand to silty sand
32.480	97.70	1.2211	1.250	2.503	23	8	sand to silty sand
32.644	97.00	1.0693	1.102	2.353	23	8	sand to silty sand
32.808	91.73	1.1351	1.237	2.375	22	8	sand to silty sand
32.972	94.46	0.9875	1.045	2.587	23	8	sand to silty sand
33.136	118.02	0.9926	0.841	2.413	28	8	sand to silty sand
33.301	132.15	1.0691	0.809	2.494	32	8	sand to silty sand
33.465	145.46	1.3673	0.940	2.254	35	8	sand to silty sand
33.629	150.14	1.5575	1.037	2.356	36	8	sand to silty sand
33.793	132.69	1.5068	1.136	2.499	32	8	sand to silty sand
33.957	123.88	1.3239	1.069	2.765	30	8	sand to silty sand
34.121	132.19	1.1998	0.908	2.603	32	8	sand to silty sand
34.285	121.07	1.7586	1.453	2.815	29	8	sand to silty sand
34.449	117.04	1.8583	1.588	2.827	28	8	sand to silty sand
34.613	123.38	1.8066	1.464	3.234	30	8	sand to silty sand
34.777	109.07	1.5301	1.403	3.410	26	8	sand to silty sand
34.941	105.20	1.1829	1.124	3.034	25	8	sand to silty sand
35.105	92.56	1.0701	1.156	3.163	22	8	sand to silty sand
35.269	79.57	2.2374	2.812	3.129	30	6	sandy silt to clayey silt
35.433	72.68	2.3763	3.270	3.082	28	6	sandy silt to clayey silt
35.597	100.56	2.2144	2.202	1.944	32	7	silty sand to sandy silt
35.761	117.49	2.5335	2.156	1.770	38	7	silty sand to sandy silt
35.925	132.71	3.0738	2.316	1.875	42	7	silty sand to sandy silt
36.089	142.82	3.3732	2.362	1.925	46	7	silty sand to sandy silt
36.253	147.16	3.3229	2.258	1.932	47	7	silty sand to sandy silt
36.417	147.97	2.5478	1.722	1.963	35	8	sand to silty sand
36.581	139.26	2.1934	1.575	1.892	33	8	sand to silty sand
36.745	106.77	3.0837	2.888	1.956	41	6	sandy silt to clayey silt
36.909	54.48	2.6762	4.912	2.185	35	4	silty clay to clay
37.073	46.82	1.8627	3.979	2.546	22	5	clayey silt to silty clay
37.238	103.08	1.3458	1.305	3.136	25	8	sand to silty sand
37.402	120.63	1.3978	1.159	2.860	29	8	sand to silty sand
37.566	124.14	1.5498	1.248	2.553	30	8	sand to silty sand
37.730	130.25	1.6319	1.253	2.465	31	8	sand to silty sand
37.894	136.82	1.5859	1.159	2.508	33	8	sand to silty sand
38.058	145.10	1.7226	1.187	2.608	35	8	sand to silty sand
38.222	153.03	1.4599	0.954	2.544	37	8	sand to silty sand
38.386	148.59	2.1846	1.470	2.720	36	8	sand to silty sand
38.550	109.10	3.1264	2.866	2.801	42	6	sandy silt to clayey silt
38.714	71.96	3.3992	4.724	2.877	69	11	very stiff fine grained (*)

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
38.878	121.33	3.1155	2.568	3.581	39	7	silty sand to sandy silt
39.042	145.23	2.2739	1.566	3.046	35	8	sand to silty sand
39.206	143.30	2.2136	1.545	3.141	34	8	sand to silty sand
39.370	158.67	2.3029	1.451	3.082	38	8	sand to silty sand
39.534	157.43	2.4773	1.574	3.089	38	8	sand to silty sand
39.698	132.34	2.6400	1.995	3.132	42	7	silty sand to sandy silt
39.862	120.84	2.8155	2.330	3.113	39	7	silty sand to sandy silt
40.026	112.99	3.2510	2.877	3.248	43	6	sandy silt to clayey silt
40.190	78.77	3.0626	3.888	3.279	38	5	clayey silt to silty clay
40.354	83.40	2.8473	3.414	3.286	32	6	sandy silt to clayey silt
40.518	83.63	2.7741	3.317	3.215	32	6	sandy silt to clayey silt
40.682	88.02	2.6918	3.058	3.267	34	6	sandy silt to clayey silt
40.846	102.91	2.7758	2.697	3.289	39	6	sandy silt to clayey silt
41.011	112.33	2.7831	2.478	3.222	36	7	silty sand to sandy silt
41.175	114.11	2.8109	2.463	3.227	36	7	silty sand to sandy silt
41.339	118.19	2.8590	2.419	3.184	38	7	silty sand to sandy silt
41.503	122.73	2.9206	2.380	3.044	39	7	silty sand to sandy silt
41.667	129.90	2.9292	2.255	3.063	41	7	silty sand to sandy silt
41.831	132.00	2.7930	2.116	2.967	42	7	silty sand to sandy silt
41.995	130.52	2.7979	2.144	2.915	42	7	silty sand to sandy silt
42.159	124.25	2.8749	2.314	2.691	40	7	silty sand to sandy silt
42.323	123.11	2.8056	2.279	2.568	39	7	silty sand to sandy silt
42.487	121.87	2.7309	2.241	2.482	39	7	silty sand to sandy silt
42.651	124.96	2.6205	2.097	2.591	40	7	silty sand to sandy silt
42.815	130.31	2.4309	1.866	2.639	42	7	silty sand to sandy silt
42.979	118.45	2.6945	2.275	2.515	38	7	silty sand to sandy silt
43.143	74.72	2.9935	4.007	2.810	36	5	clayey silt to silty clay
43.307	58.79	2.9162	4.961	2.868	38	4	silty clay to clay
43.471	66.77	2.8787	4.311	3.393	32	5	clayey silt to silty clay
43.635	94.45	3.1527	3.338	3.048	36	6	sandy silt to clayey silt
43.799	73.08	2.8634	3.918	3.036	35	5	clayey silt to silty clay
43.963	71.73	2.3895	3.331	3.146	27	6	sandy silt to clayey silt
44.127	88.98	2.2433	2.521	3.022	34	6	sandy silt to clayey silt
44.291	90.81	2.0351	2.241	2.760	29	7	silty sand to sandy silt
44.455	90.45	2.0871	2.307	2.813	29	7	silty sand to sandy silt
44.619	101.58	2.3659	2.329	2.722	32	7	silty sand to sandy silt
44.783	133.68	2.5477	1.906	2.649	43	7	silty sand to sandy silt
44.948	154.91	2.6955	1.740	2.596	37	8	sand to silty sand
45.112	159.00	2.5541	1.606	2.387	38	8	sand to silty sand
45.276	146.24	2.8935	1.979	2.580	47	7	silty sand to sandy silt
45.440	158.69	2.7945	1.761	2.304	38	8	sand to silty sand
45.604	149.58	3.6363	2.431	2.189	48	7	silty sand to sandy silt
45.768	115.46	4.1729	3.614	2.144	44	6	sandy silt to clayey silt
45.932	97.65	4.2241	4.326	2.470	94	11	very stiff fine grained (*)
46.096	118.27	3.6285	3.068	2.396	45	6	sandy silt to clayey silt
46.260	87.18	3.4768	3.988	2.444	42	5	clayey silt to silty clay
46.424	72.77	3.4813	4.784	2.672	70	11	very stiff fine grained (*)
46.588	106.34	3.6432	3.426	2.713	41	6	sandy silt to clayey silt
46.752	123.38	3.1466	2.550	2.489	39	7	silty sand to sandy silt
46.916	131.56	3.0792	2.341	2.446	42	7	silty sand to sandy silt
47.080	129.44	2.9383	2.270	2.308	41	7	silty sand to sandy silt
47.244	124.91	2.9205	2.338	2.375	40	7	silty sand to sandy silt
47.408	124.71	2.8783	2.308	2.358	40	7	silty sand to sandy silt
47.572	126.91	2.9625	2.334	2.265	41	7	silty sand to sandy silt
47.736	128.31	3.4356	2.678	2.418	41	7	silty sand to sandy silt
47.900	124.96	4.1435	3.316	2.439	48	6	sandy silt to clayey silt
48.064	91.07	4.0037	4.396	2.534	87	11	very stiff fine grained (*)

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
48.228	59.40	4.1466	6.981	2.551	57	11	very stiff fine grained (*)
48.392	88.79	4.5435	5.117	3.453	85	11	very stiff fine grained (*)
48.556	120.69	4.1136	3.408	3.248	46	6	sandy silt to clayey silt
48.720	163.27	3.0479	1.867	2.775	52	7	silty sand to sandy silt
48.885	200.19	1.8523	0.925	2.537	38	9	sand
49.049	227.65	1.5267	0.671	2.442	44	9	sand
49.213	204.97	1.2951	0.632	2.453	39	9	sand
49.377	171.16	1.2649	0.739	2.627	33	9	sand
49.541	162.90	1.3157	0.808	2.601	31	9	sand
49.705	155.66	2.0104	1.292	2.525	37	8	sand to silty sand
49.869	135.66	3.4857	2.569	2.608	43	7	silty sand to sandy silt
50.033	101.93	4.0527	3.976	2.791	49	5	clayey silt to silty clay
50.197	105.14	4.1798	3.975	3.491	50	5	clayey silt to silty clay
50.361	145.00	3.2947	2.272	3.310	46	7	silty sand to sandy silt
50.525	142.58	2.2279	1.563	3.141	34	8	sand to silty sand
50.689	147.83	2.3339	1.579	3.072	35	8	sand to silty sand
50.853	145.34	2.4364	1.676	3.013	35	8	sand to silty sand
51.017	139.79	2.0045	1.434	3.070	33	8	sand to silty sand
51.181	134.81	1.1866	0.880	3.153	32	8	sand to silty sand
51.345	135.17	0.8347	0.618	3.113	26	9	sand
51.509	136.91	0.6088	0.445	3.063	26	9	sand
51.673	110.75	0.6271	0.566	3.108	27	8	sand to silty sand
51.837	99.56	0.7268	0.730	2.922	24	8	sand to silty sand
52.001	102.43	1.2330	1.204	2.163	25	8	sand to silty sand
52.165	102.22	2.4328	2.380	2.204	33	7	silty sand to sandy silt
52.329	58.33	2.2098	3.788	2.035	28	5	clayey silt to silty clay
52.493	37.91	1.5626	4.121	2.349	24	4	silty clay to clay
52.657	26.32	1.6766	6.371	2.611	25	3	clay
52.822	36.36	2.1524	5.920	3.003	35	3	clay
52.986	66.08	2.1357	3.232	2.701	25	6	sandy silt to clayey silt
53.150	103.39	2.3407	2.264	2.096	33	7	silty sand to sandy silt
53.314	113.59	2.2996	2.024	2.158	36	7	silty sand to sandy silt
53.478	98.99	2.1987	2.221	2.163	32	7	silty sand to sandy silt
53.642	97.76	2.0126	2.059	2.001	31	7	silty sand to sandy silt
53.806	91.35	2.9198	3.196	2.125	35	6	sandy silt to clayey silt
53.970	78.13	3.2335	4.138	2.020	37	5	clayey silt to silty clay
54.134	93.58	1.9887	2.125	2.047	30	7	silty sand to sandy silt
54.298	106.46	1.5120	1.420	1.813	25	8	sand to silty sand
54.462	100.24	1.9850	1.980	1.892	32	7	silty sand to sandy silt
54.626	94.96	2.8710	3.023	1.785	36	6	sandy silt to clayey silt
54.790	101.21	2.6386	2.607	1.692	39	6	sandy silt to clayey silt
54.954	117.38	2.5767	2.195	1.775	37	7	silty sand to sandy silt
55.118	110.69	2.9577	2.672	1.701	42	6	sandy silt to clayey silt
55.282	40.03	2.4442	6.105	1.544	38	3	clay
55.446	25.66	1.7208	6.705	1.466	25	3	clay
55.610	28.42	1.1442	4.026	1.728	18	4	silty clay to clay
55.774	28.38	1.1944	4.209	1.759	18	4	silty clay to clay
55.938	26.86	2.0136	7.495	1.954	26	3	clay
56.102	53.94	2.8059	5.202	2.168	52	3	clay
56.266	77.78	2.9307	3.768	1.732	37	5	clayey silt to silty clay
56.430	93.96	2.2106	2.353	1.547	30	7	silty sand to sandy silt
56.594	111.20	1.9877	1.787	1.385	35	7	silty sand to sandy silt
56.759	99.85	2.5585	2.562	1.366	38	6	sandy silt to clayey silt
56.923	79.47	3.3360	4.198	1.330	38	5	clayey silt to silty clay
57.087	66.40	3.6390	5.481	1.399	64	11	very stiff fine grained (*)
57.251	63.13	3.6002	5.703	1.397	60	11	very stiff fine grained (*)
57.415	65.72	3.4983	5.323	1.206	63	11	very stiff fine grained (*)

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
57.579	72.52	3.3527	4.623	1.276	46	4	silty clay to clay
57.743	84.90	3.1248	3.680	1.325	41	5	clayey silt to silty clay
57.907	95.36	3.0330	3.181	1.383	37	6	sandy silt to clayey silt
58.071	102.11	3.1808	3.115	1.147	39	6	sandy silt to clayey silt
58.235	104.01	3.9008	3.750	1.280	40	6	sandy silt to clayey silt
58.399	91.64	3.4915	3.810	1.330	44	5	clayey silt to silty clay
58.563	65.43	3.9130	5.980	1.273	63	11	very stiff fine grained (*)
58.727	63.59	3.0314	4.767	1.302	41	4	silty clay to clay
58.891	54.21	2.1499	3.966	1.064	26	5	clayey silt to silty clay
59.055	27.59	1.6427	5.955	1.261	26	3	clay
59.219	30.78	1.3234	4.300	1.252	20	4	silty clay to clay
59.383	23.75	0.9833	4.141	1.428	15	4	silty clay to clay
59.547	24.24	0.8700	3.589	1.430	12	5	clayey silt to silty clay
59.711	21.98	0.8305	3.778	1.640	14	4	silty clay to clay
59.875	23.56	0.9088	3.858	1.490	15	4	silty clay to clay
60.039	26.94	0.9883	3.668	1.618	13	5	clayey silt to silty clay
60.203	28.34	1.2456	4.394	1.602	18	4	silty clay to clay
60.367	31.10	1.3974	4.493	1.825	20	4	silty clay to clay
60.532	33.65	1.7036	5.062	1.725	32	3	clay
60.696	34.78	1.9113	5.495	1.859	33	3	clay
60.860	34.76	2.0204	5.812	1.849	33	3	clay
61.024	36.42	2.0746	5.697	2.039	35	3	clay
61.188	37.85	2.0242	5.347	2.118	36	3	clay
61.352	38.41	2.0271	5.278	2.180	37	3	clay
61.516	41.25	2.2484	5.451	2.304	39	3	clay
61.680	46.25	2.6125	5.649	2.539	44	3	clay
61.844	43.05	2.6873	6.243	4.034	41	3	clay
62.008	39.22	2.4415	6.225	3.984	38	3	clay
62.172	36.97	1.9714	5.333	4.038	35	3	clay
62.336	35.13	1.8193	5.179	4.191	34	3	clay
62.500	35.09	1.7632	5.025	4.267	34	3	clay
62.664	35.91	1.9357	5.391	4.374	34	3	clay
62.828	35.49	1.9323	5.444	4.329	34	3	clay
62.992	35.21	1.7420	4.948	4.483	34	3	clay
63.156	33.54	1.6160	4.819	4.602	32	3	clay
63.320	34.36	1.7986	5.234	4.636	33	3	clay
63.484	33.41	1.8498	5.537	4.593	32	3	clay
63.648	31.87	1.6468	5.167	4.433	31	3	clay
63.812	30.00	1.4888	4.962	4.509	29	3	clay
63.976	29.15	1.4433	4.951	4.709	28	3	clay
64.140	28.90	1.3677	4.733	4.621	28	3	clay
64.304	29.56	1.3863	4.690	4.502	28	3	clay
64.469	31.36	1.5111	4.819	4.626	30	3	clay
64.633	31.56	1.5442	4.893	4.764	30	3	clay
64.797	30.75	1.5582	5.068	4.776	29	3	clay
64.961	31.73	1.6993	5.356	4.669	30	3	clay
65.125	34.55	1.6672	4.825	4.893	33	3	clay
65.289	33.98	1.5644	4.604	5.140	22	4	silty clay to clay
65.453	33.46	1.4731	4.402	5.176	21	4	silty clay to clay
65.617	35.07	1.5775	4.498	5.085	22	4	silty clay to clay
65.781	37.93	1.6463	4.340	5.326	24	4	silty clay to clay
65.945	38.28	1.7703	4.624	5.385	24	4	silty clay to clay
66.109	39.42	1.6492	4.184	5.799	25	4	silty clay to clay
66.273	35.87	1.5848	4.419	5.944	23	4	silty clay to clay
66.437	38.85	1.5367	3.955	6.251	19	5	clayey silt to silty clay
66.601	40.76	1.5090	3.702	6.337	20	5	clayey silt to silty clay
66.765	41.53	1.4857	3.578	6.458	20	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
66.929	40.98	1.4430	3.522	6.708	20	5	clayey silt to silty clay
67.093	40.05	1.5144	3.781	6.718	19	5	clayey silt to silty clay
67.257	39.05	1.5053	3.855	6.892	19	5	clayey silt to silty clay
67.421	38.60	1.4915	3.864	6.911	18	5	clayey silt to silty clay
67.585	37.21	1.4511	3.900	7.099	18	5	clayey silt to silty clay
67.749	38.14	1.4463	3.793	7.222	18	5	clayey silt to silty clay
67.913	37.61	1.4981	3.983	7.318	18	5	clayey silt to silty clay
68.077	36.62	1.4293	3.903	7.332	18	5	clayey silt to silty clay
68.241	37.27	1.5241	4.089	7.275	24	4	silty clay to clay
68.406	37.62	1.5948	4.239	7.674	24	4	silty clay to clay
68.570	37.60	1.5956	4.243	8.012	24	4	silty clay to clay
68.734	36.75	1.6068	4.373	8.115	23	4	silty clay to clay
68.898	35.79	1.4731	4.116	8.084	23	4	silty clay to clay
69.062	33.97	1.3006	3.829	8.200	16	5	clayey silt to silty clay
69.226	34.01	1.2653	3.720	8.174	16	5	clayey silt to silty clay
69.390	35.82	1.3151	3.671	8.188	17	5	clayey silt to silty clay
69.554	34.55	1.3732	3.974	8.260	22	4	silty clay to clay
69.718	32.87	1.3006	3.957	8.334	21	4	silty clay to clay
69.882	32.09	1.2730	3.966	8.315	20	4	silty clay to clay
70.046	31.44	1.2086	3.844	8.441	15	5	clayey silt to silty clay
70.210	30.36	1.1628	3.830	8.633	15	5	clayey silt to silty clay
70.374	28.55	1.0357	3.627	8.710	14	5	clayey silt to silty clay
70.538	27.60	0.8467	3.067	8.536	13	5	clayey silt to silty clay
70.702	26.27	0.7450	2.836	8.567	13	5	clayey silt to silty clay
70.866	25.88	0.7213	2.786	8.719	12	5	clayey silt to silty clay
71.030	24.91	0.6543	2.626	8.814	12	5	clayey silt to silty clay
71.194	23.91	0.6341	2.652	8.836	11	5	clayey silt to silty clay
71.358	23.06	0.4092	1.774	8.900	9	6	sandy silt to clayey silt
71.522	21.39	0.4275	1.998	8.981	8	6	sandy silt to clayey silt
71.686	21.55	0.4259	1.976	9.109	8	6	sandy silt to clayey silt
71.850	21.64	0.4100	1.894	9.269	8	6	sandy silt to clayey silt
72.014	22.37	0.4266	1.907	9.155	9	6	sandy silt to clayey silt
72.178	22.44	0.4236	1.887	9.293	9	6	sandy silt to clayey silt
72.343	23.98	0.6129	2.556	9.495	11	5	clayey silt to silty clay
72.507	30.80	0.8084	2.625	9.785	12	6	sandy silt to clayey silt
72.671	34.06	1.0210	2.997	9.999	16	5	clayey silt to silty clay
72.835	30.01	0.7098	2.365	9.823	11	6	sandy silt to clayey silt
72.999	22.58	0.5210	2.307	9.890	11	5	clayey silt to silty clay
73.163	21.51	0.3804	1.769	10.102	8	6	sandy silt to clayey silt
73.327	19.94	0.4040	2.026	10.318	8	6	sandy silt to clayey silt
73.491	20.98	0.4231	2.017	10.497	8	6	sandy silt to clayey silt
73.655	20.37	0.4300	2.111	10.801	10	5	clayey silt to silty clay
73.819	20.95	0.6007	2.867	10.694	10	5	clayey silt to silty clay
73.983	27.25	0.8721	3.201	11.087	13	5	clayey silt to silty clay
74.147	36.15	1.4619	4.044	11.213	23	4	silty clay to clay
74.311	43.15	1.7868	4.141	10.954	28	4	silty clay to clay
74.475	38.88	2.5861	6.652	11.791	37	3	clay
74.639	54.69	3.1788	5.812	11.967	52	3	clay
74.803	46.77	2.3588	5.044	11.606	45	3	clay
74.967	41.75	3.5740	8.560	12.931	40	3	clay
75.131	82.12	4.1743	5.083	15.040	79	11	very stiff fine grained (*)
75.295	81.72	3.7859	4.633	16.579	78	11	very stiff fine grained (*)
75.459	58.04	2.5604	4.412	17.412	37	4	silty clay to clay
75.623	58.33	2.5387	4.352	18.495	28	5	clayey silt to silty clay
75.787	80.51	3.8736	4.811	19.708	77	11	very stiff fine grained (*)
75.951	124.45	5.8589	4.708	23.373	119	11	very stiff fine grained (*)
76.115	85.20	5.5574	6.523	20.867	82	11	very stiff fine grained (*)

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
76.280	43.33	3.7014	8.542	16.796	41	3	clay
76.444	31.61	1.6724	5.291	16.936	30	3	clay
76.608	22.82	1.0978	4.812	17.362	22	3	clay
76.772	20.59	0.8519	4.137	17.541	13	4	silty clay to clay
76.936	21.31	0.9017	4.232	17.662	14	4	silty clay to clay
77.100	25.98	0.8513	3.277	17.760	12	5	clayey silt to silty clay
77.264	22.88	0.9635	4.212	18.174	15	4	silty clay to clay
77.428	27.94	1.1791	4.220	18.514	18	4	silty clay to clay
77.592	34.69	1.4080	4.059	18.431	22	4	silty clay to clay
77.756	33.06	1.3386	4.049	18.990	21	4	silty clay to clay
77.920	33.17	2.4177	7.288	19.490	32	3	clay
78.084	55.30	4.7310	8.555	19.659	53	3	clay
78.248	150.13	5.7873	3.855	14.454	72	12	sand to clayey sand (*)
78.412	103.82	6.7874	6.538	12.860	99	11	very stiff fine grained (*)
78.576	89.47	6.7029	7.492	12.241	86	11	very stiff fine grained (*)
78.740	129.84	7.7809	5.993	16.298	124	11	very stiff fine grained (*)
78.904	174.10	8.9866	5.162	20.218	167	11	very stiff fine grained (*)
79.068	170.93	8.9288	5.224	16.106	164	11	very stiff fine grained (*)
79.232	157.48	7.5656	4.804	14.454	151	11	very stiff fine grained (*)
79.396	136.38	7.2119	5.288	11.603	131	11	very stiff fine grained (*)
79.560	110.00	8.0325	7.303	10.927	105	11	very stiff fine grained (*)
79.724	116.26	8.6513	7.441	11.296	111	11	very stiff fine grained (*)
79.888	120.53	7.7836	6.458	10.225	115	11	very stiff fine grained (*)
80.052	95.65	8.0616	8.429	10.647	92	11	very stiff fine grained (*)
80.217	153.50	8.1321	5.298	14.116	147	11	very stiff fine grained (*)
80.381	191.31	7.2519	3.791	11.668	92	12	sand to clayey sand (*)

Appendix D
Laboratory Test Results

FEI TESTING & INSPECTION, INC.
Geotechnical & Construction Services

LETTER OF TRANSMITTAL

Date: October 13, 2023

Project No.: 2226031-606

Re: Durham WRRF Phase 6B
Digester Preliminary Design

Jacobs Project No. D3704504

To: Jacobs
2020 SW 4th Ave. Suite 300
Portland, OR 97201

Attn: Ajith Hanagoodu Raghavendra

Enclosed are:

☐ Report ☐ Drawings ☑ Test Results (21 Pages Total Incl. Cover)
☐ Copy of Letter ☐ Specifications
☐ Other

These are transmitted as checked below:

☑ For your use ☐ For your review/approval
☑ As requested ☐ For your files

Remarks: Requested laboratory testing results attached. Please call if you have any questions.

Dates Sampled: various
Location Tested: Corvallis Laboratory
Sample No.: 9180

Copy to:
Aynaz Biniyaz - Jacobs

Signature:
Rachel Ray

Rachel Ray
President

This report and/or enclosed test data is the confidential property of the client to whom it is addressed and pertains to the specific process and/or material evaluated. As such, information contained herein shall not be reproduced in part or full and/or any part thereof be disclosed without FEI Testing & Inspection, Inc.'s written authorization.

FEI TESTING & INSPECTION, INC.
Geotechnical & Construction Services

Percent Fines & Water Content Test (ASTM D 1140)

PROJECT NAME	***Durham WRRF Phase 6B Digester***	*PROJECT NUMBER*	***2236031-606***
RECORDED BY	***CP***	*FEI SAMPLE NUMBER*	***9180***
CLIENT	***Jacobs***	*DATE*	***9/19/2023***
REMARKS		*CLIENT PROJECT NUMBER*	***D3704504***

WATER CONTENT DIR or AUX*	***DIR***	***DIR***	***DIR***	***DIR***	***DIR***	***DIR***	
SAMPLE DESIGNATION	**B-01, SS-3**	**B-01, SS-5**	**B-01, SS-10-A**	**B-01, ST-13**	**B-01, SS-21**	**B-01, SS-7**	
SAMPLE DEPTH (FT)	**8.5-10.0**	**15.0-16.5**	**40.0-41.0**	**46.5-48.5**	**80.0-81.5**	**25.0-26.5**	
Pan Number	34	36	30	22	6	65	
Wt. of Wet Soil + Pan (g)	270.79	212.72	254.50	284.53	323.27	275.24	
Wt. of Dry Soil + Pan (g)	224.30	184.45	223.12	230.49	258.48	237.70	
Wt. of Water (g)	46.49	28.27	31.38	54.04	64.79	37.54	
Wt. of Pan (g)	79.82	79.86	80.90	70.30	75.81	79.08	
Wt. of Dry Soil (g)	144.48	104.59	142.22	160.19	182.67	158.62	
Water Content (%)	**32.2%**	**27.0%**	**22.1%**	**33.7%**	**35.5%**	**23.7%**	

TEST SAMPLE DATA							
TEST METHOD A or B	**B**	**B**	**B**	**B**	**B**	**B**	
Length of Time Sample Soaked (hrs	**4**	**4**	**4**	**4**	**4**	**4**	
Pan Number	34	36	30	22	6	65	
Wet Wt. + Pan (g)	270.79	212.72	254.50	284.53	323.27	275.24	
Wet Wt. (g)	190.97	132.86	173.60	214.23	247.46	237.70	
Wt. of Pan (g)	79.82	79.86	80.90	70.30	75.81	79.08	
(A) Dry Soil (g) (Total Sample)	144.48	104.59	142.22	160.19	182.67	158.62	

AFTER WASHING							
Pan Number	34	36	30	22	6	65	
Dry Wt. + Pan (g)	133.54	156.21	188.65	125.87	141.75	187.72	
Wt. of Pan (g)	79.82	79.86	80.90	70.30	75.81	79.08	
(B) Wt. of Dry Soil	53.72	76.35	107.75	55.57	65.94	108.64	
(C) Total Loss (g) (No. 200) (C=A-B)	90.76	28.24	34.47	104.62	116.73	49.98	
(D) Wt. of material retained on #4	0.00	0.00	0.00	1.22	0.00	0.00	
% Fines (C/A)	**62.8%**	**27.0%**	**24.2%**	**65.3%**	**63.9%**	**31.5%**	
% + #4 (D/A)	**0.0%**	**0.0%**	**0.0%**	**0.8%**	**0.0%**	**0.0%**	

*DIR=Dry mass was determined directly by drying the test specimen

*AUX=Dry mass was determined using an auxiliary water content specimen

Equipment Used

Oven ID #	**6060**
Scale ID #	**6376**
Sieve ID #	**6373**

Reviewed By Rachel Ray

FEI TESTING & INSPECTION, INC.
Geotechnical & Construction Services

Percent Fines & Water Content Test (ASTM D 1140)

PROJECT NAME	***Durham WRRF Phase 6B Digester***	*PROJECT NUMBER*	***2236031-606***
RECORDED BY	***CP***	*FEI SAMPLE NUMBER*	***9180***
CLIENT	***Jacobs***	*DATE*	***9/19/2023***
REMARKS		*CLIENT PROJECT NUMBER*	***D3704504***

WATER CONTENT DIR or AUX*	***DIR***	***DIR***	***DIR***	***DIR***	***DIR***	***DIR***	***DIR***
SAMPLE DESIGNATION	**B-02, SS-3**	**B-02, ST-5**	**B-02, SS-8**	**B-02, SS-11**	**B-02, ST-13**	**B-02, SS-14-B**	**B-02, SS-19**
SAMPLE DEPTH (FT)	**10.0-11.5**	**16.5-18.5**	**25.0-26.5**	**40.0-41.5**	**46.5-48.8**	**50.25-51.5**	**75.0-76.5**
Pan Number	8	18	15	37	20	23	31
Wt. of Wet Soil + Pan (g)	248.39	204.85	247.22	301.07	357.56	289.07	358.08
Wt. of Dry Soil + Pan (g)	210.90	154.40	201.70	261.95	299.79	238.66	280.87
Wt. of Water (g)	37.49	50.45	45.52	39.12	57.77	50.41	77.21
Wt. of Pan (g)	76.21	70.03	70.41	79.97	69.94	69.89	80.32
Wt. of Dry Soil (g)	134.69	84.37	131.29	181.98	229.85	168.77	200.55
Water Content (%)	**27.8%**	**59.8%**	**34.7%**	**21.5%**	**25.1%**	**29.9%**	**38.5%**

TEST SAMPLE DATA							
TEST METHOD A or B	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Length of Time Sample Soaked (hrs	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Pan Number	8	18	15	37	20	23	31
Wet Wt. + Pan (g)	248.39	204.85	247.22	301.07	357.56	289.07	358.08
Wet Wt. (g)	172.18	134.82	176.81	221.10	287.62	219.18	277.76
Wt. of Pan (g)	76.21	70.03	70.41	79.97	69.94	69.89	80.32
(A) Dry Soil (g) (Total Sample)	134.69	84.37	131.29	181.98	229.85	168.77	200.55

AFTER WASHING							
Pan Number	8	18	15	37	20	23	31
Dry Wt. + Pan (g)	149.86	113.75	129.83	186.66	250.57	113.19	206.81
Wt. of Pan (g)	76.21	70.03	70.41	79.97	69.94	69.89	80.32
(B) Wt. of Dry Soil	73.65	43.72	59.42	106.69	180.63	43.30	126.49
(C) Total Loss (g) (No. 200) (C=A-B)	61.04	40.65	71.87	75.29	49.22	125.47	74.06
(D) Wt. of material retained on #4	0.00	0.00	0.00	0.00	11.76	0.61	1.83
% Fines (C/A)	**45.3%**	**48.2%**	**54.7%**	**41.4%**	**21.4%**	**74.3%**	**36.9%**
% + #4 (D/A)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**5.1%**	**0.4%**	**0.9%**

*DIR=Dry mass was determined directly by drying the test specimen

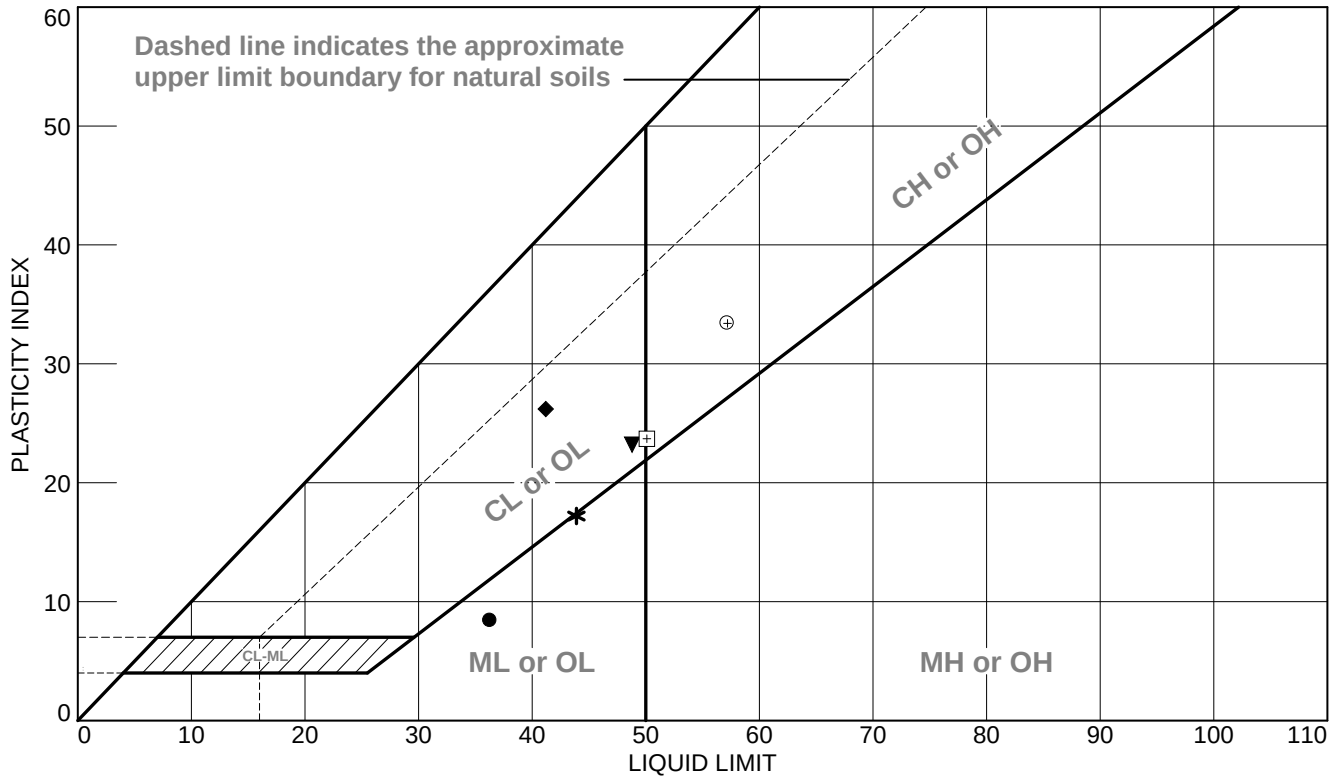
*AUX=Dry mass was determined using an auxiliary water content specimen

Equipment Used

Oven ID #	**6060**
Scale ID #	**6376**
Sieve ID #	**6373**

Reviewed By Rachel Ray

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	9180	B-01, SS-3	8.5-10.0'	32.2	27.9	36.3	8.4	ML
■	9180	B-01, SS-5	15.0-16.5'	27.0	NP	NV	NP	NP
▲	9180	B-01, SS-10-A	40.0-41.0'	22.1	NP	NV	NP	NP
◆	9180	B-01, ST-13	46.5-48.5'	33.7	15.0	41.2	26.2	CL
▼	9180	B-01, SS-15	55.0-56.5'	38.2	25.6	48.8	23.2	CL
✱	9180	B-01, SS-18-A	65.0-66.0'	38.9	26.7	43.9	17.2	ML
⊕	9180	B-01, SS-21	80.0-81.5'	35.5	23.8	57.2	33.4	CH
⊞	9180	B-01, SS-25	100.0-101.5'	38.0	26.4	50.1	23.7	CH

FEI Testing & Inspection, Inc.

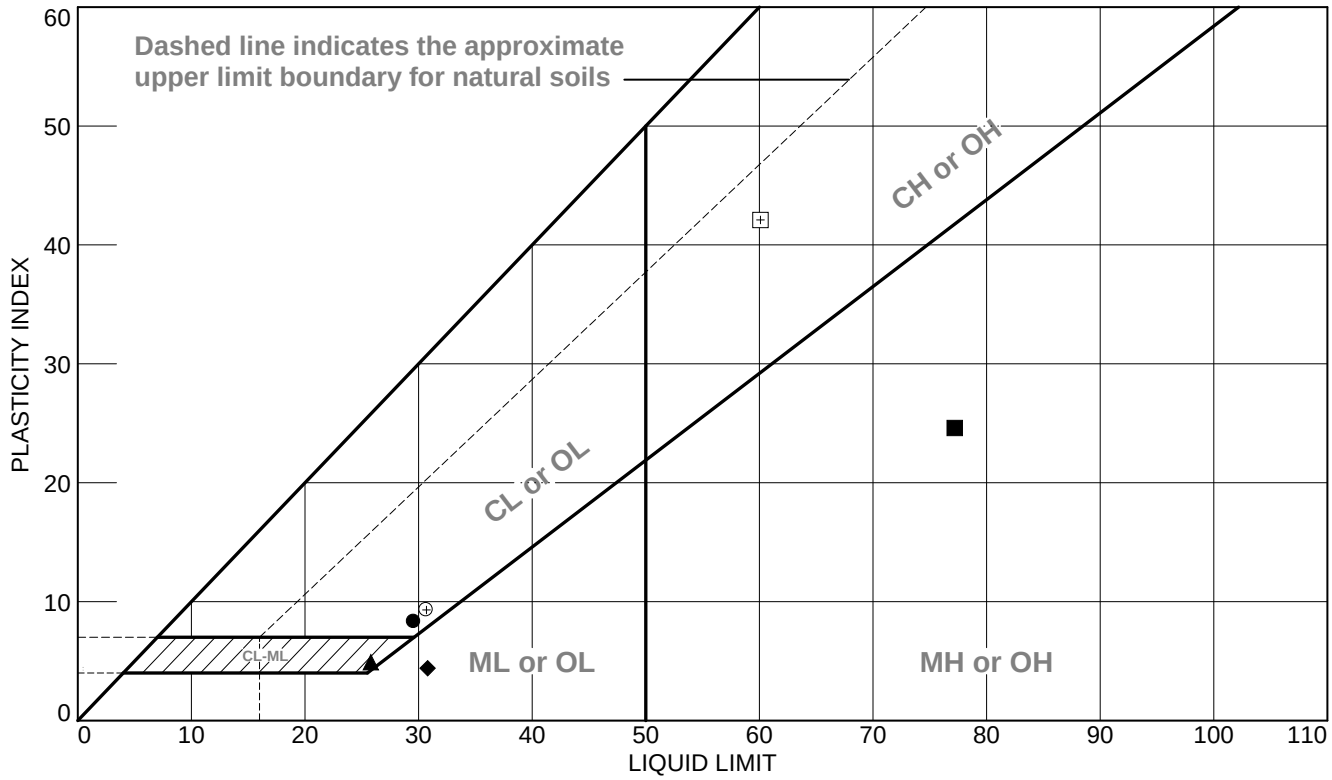
Corvallis, OR

Client: Jacobs (D3704504)

Project: Durham WRRF Phase 6B Digester Preliminary Design

Project No.: 2236031-606 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	9180	B-02, SS-3	10.0-11.5'	27.8	21.3	29.6	8.3	CL
■	9180	B-02, ST-5	16.5-18.5'	59.8	52.6	77.2	24.6	MH
▲	9180	B-02, SS-6	20.0-21.4'	26.4	20.9	25.8	4.9	CL-ML
◆	9180	B-02, SS-8	25.0-26.5'	34.7	26.4	30.8	4.4	ML
▼	9180	B-02, SS-11	40.0-41.5'	21.5	NP	NV	NP	NP
✳	9180	B-02, ST-13	46.5-48.8'	25.1	NP	NV	NP	NP
⊕	9180	B-02, SS-14-B	50.25-51.5'	29.9	21.4	30.7	9.3	CL
⊞	9180	B-02, SS-17	65.0-66.5'	30.0	18.0	60.1	42.1	CH

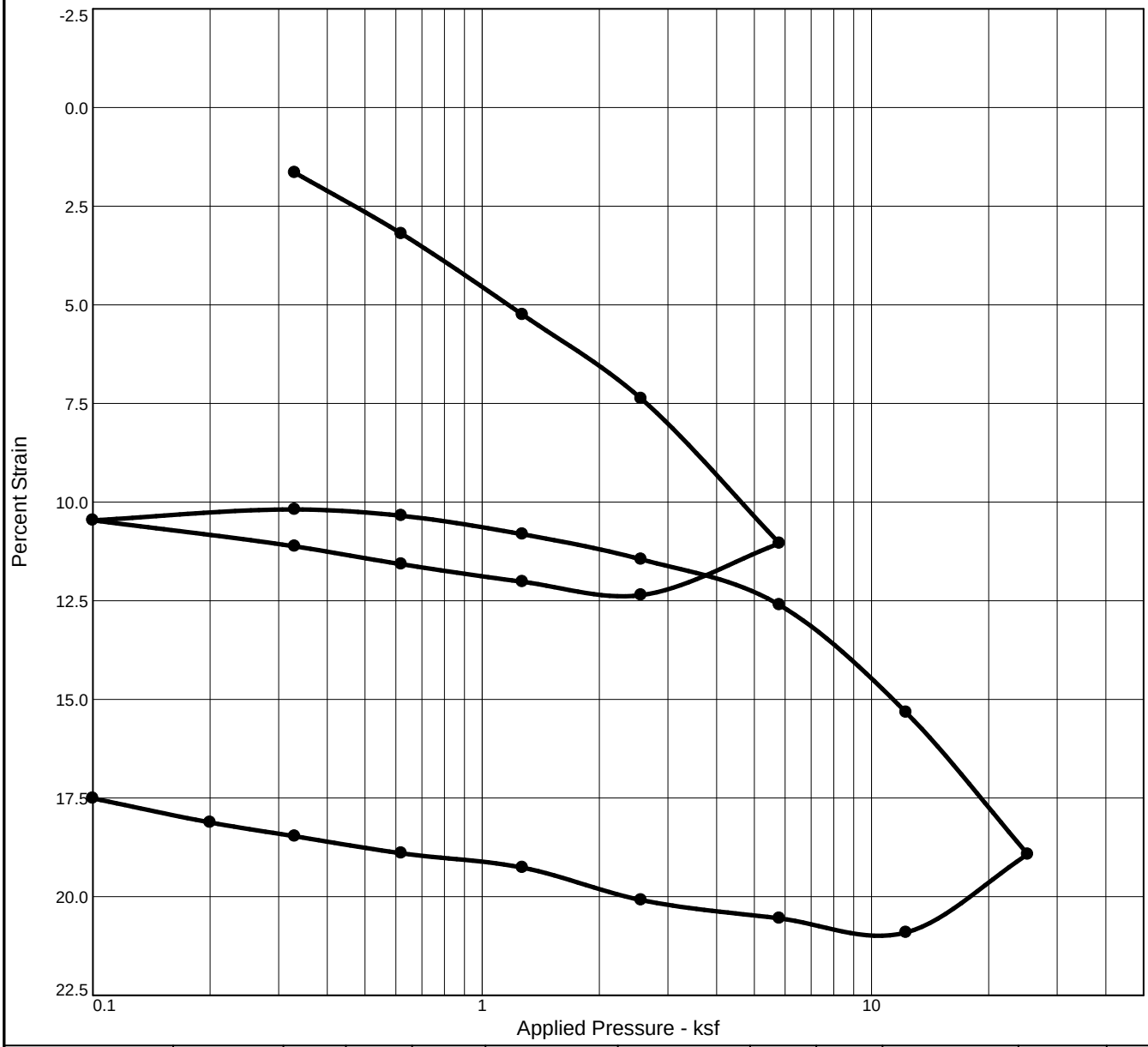
FEI Testing & Inspection, Inc.

Corvallis, OR

Client: Jacobs (D3704504)
Project: Durham WRRF Phase 6B Digester Preliminary Design

Project No.: 2236031-606 **Figure**

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_r	Swell Press. (ksf)	Swell %	e_o
Sat.	Moist.											
	31.3 %	78.9	77.2	24.6		.01	3.0					

MATERIAL DESCRIPTION	USCS	AASHTO
	MH	

Project No. 2236031-606 **Client:** Jacobs (D3704504)

Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 **Depth:** 16.5-18.5' **Sample Number:** B-02, ST-5

Remarks:

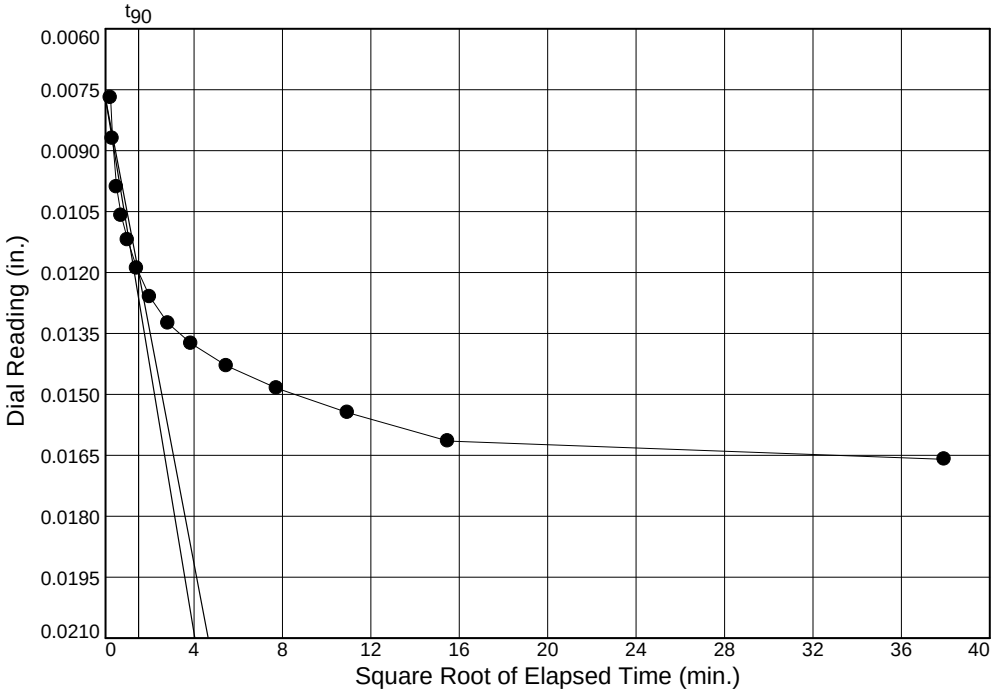
FEI Testing & Inspection, Inc.
Corvallis, OR

Figure

Dial Reading vs. Time

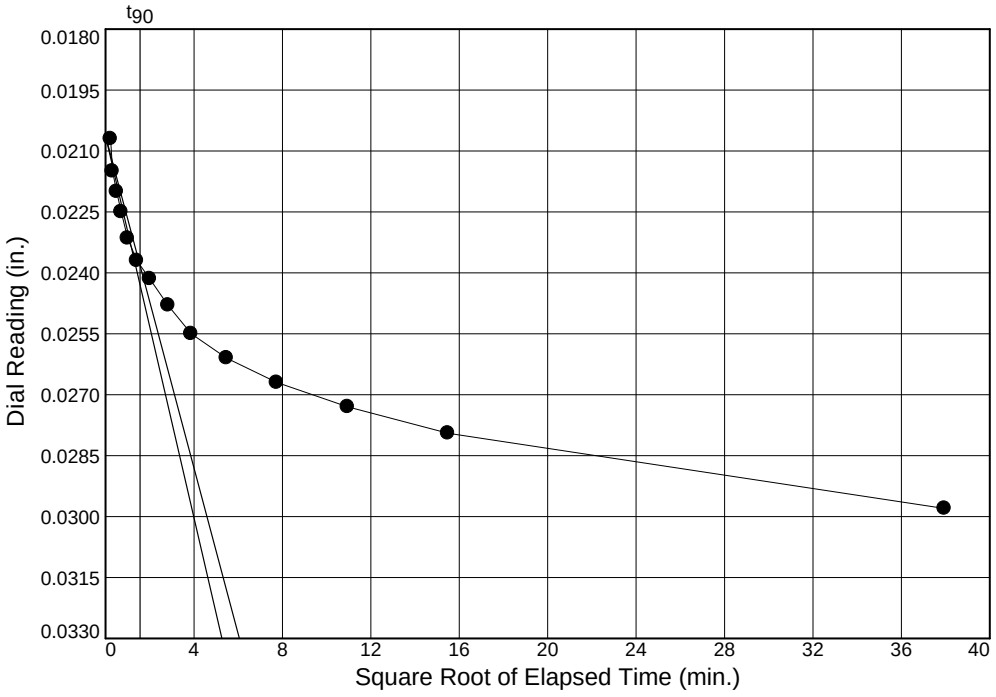
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 1
Load= 0.33 ksf
D_0 = 0.0077
D_{90} = 0.0120
D_{100} = 0.0125
T_{90} = 2.24 min.

C_v @ T_{90}
0.527 ft.^{2}/day



Load No.= 2
Load= 0.62 ksf
D_0 = 0.0206
D_{90} = 0.0238
D_{100} = 0.0242
T_{90} = 2.42 min.

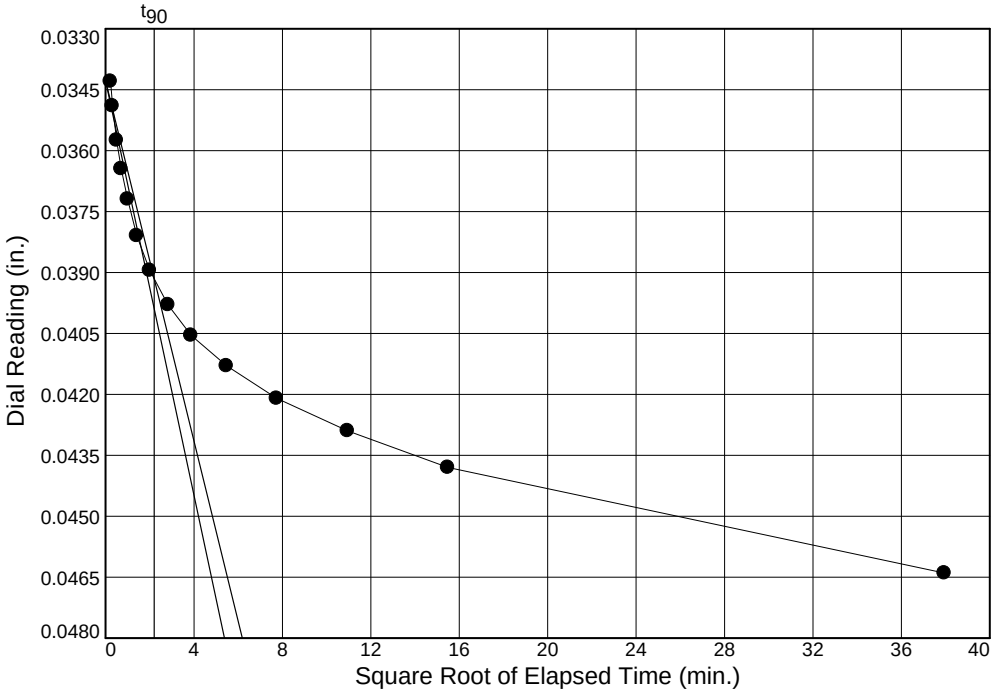
C_v @ T_{90}
0.471 ft.^{2}/day

Figure

Dial Reading vs. Time

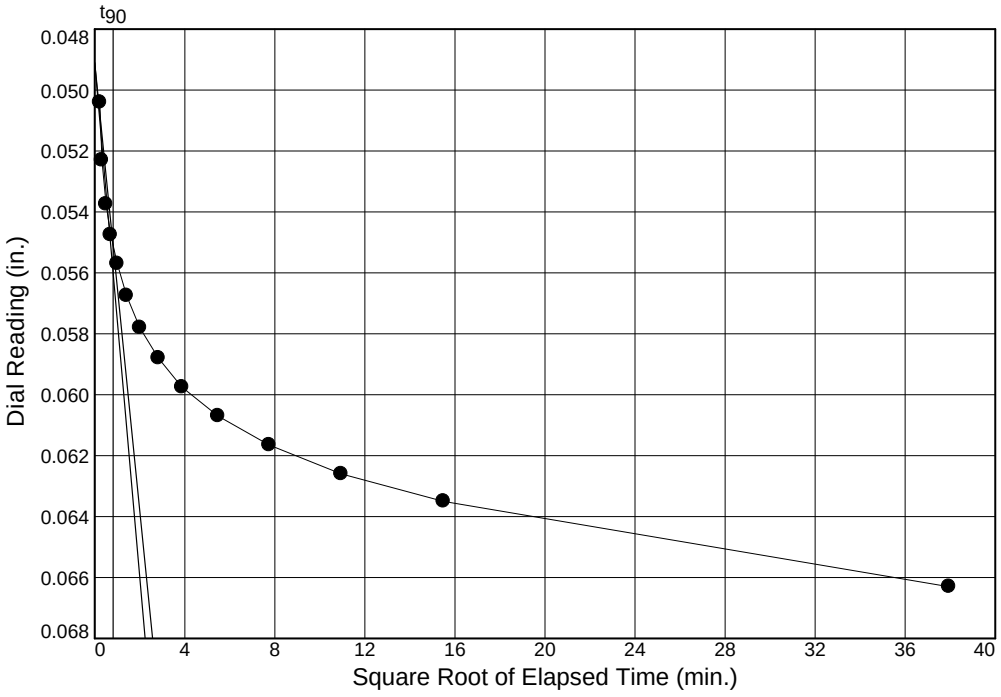
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 3
Load= 1.27 ksf
D_0 = 0.0343
D_{90} = 0.0392
D_{100} = 0.0397
T_{90} = 4.83 min.

C_v @ T_{90}
0.227 ft.^{2}/day



Load No.= 4
Load= 2.56 ksf
D_0 = 0.0491
D_{90} = 0.0551
D_{100} = 0.0558
T_{90} = 0.66 min.

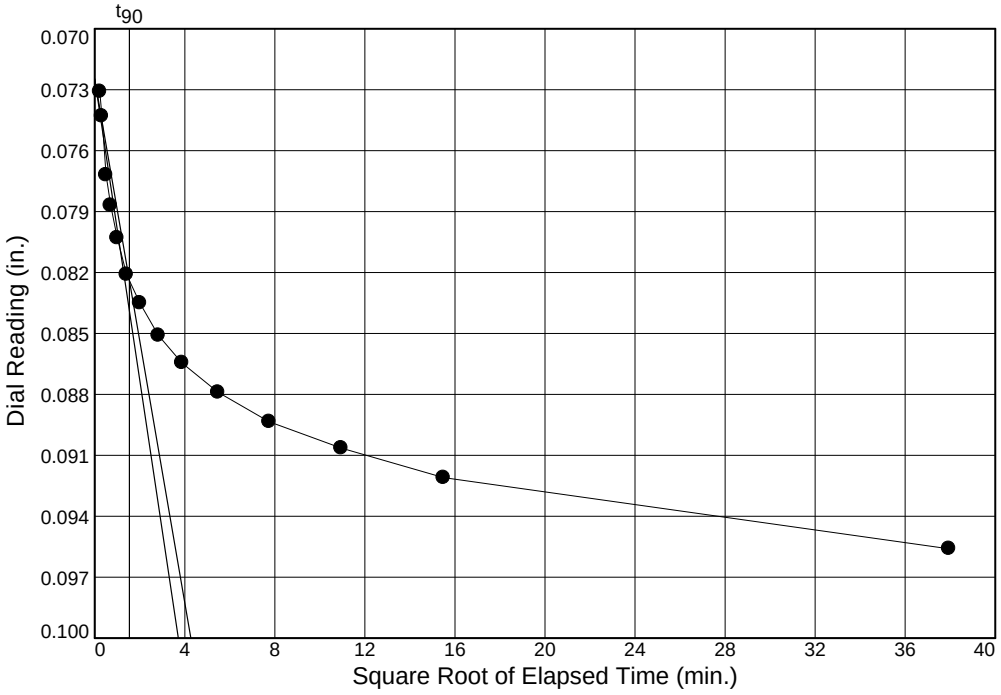
C_v @ T_{90}
1.580 ft.^{2}/day

Figure

Dial Reading vs. Time

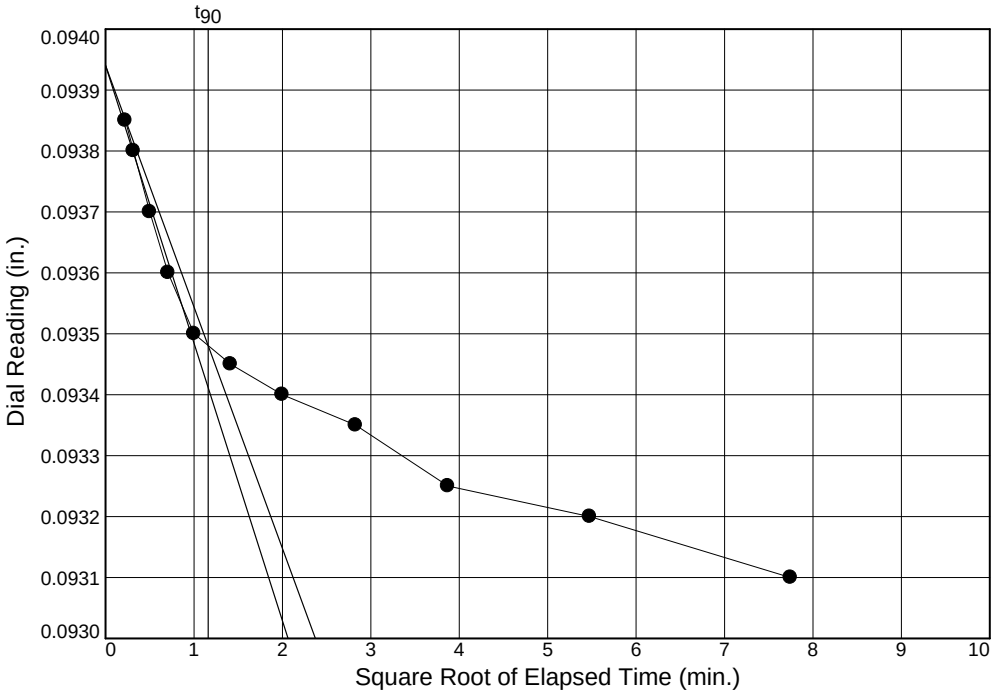
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 5
Load= 5.80 ksf
D_0 = 0.0725
D_{90} = 0.0824
D_{100} = 0.0835
T_{90} = 2.37 min.

C_v @ T_{90}
0.412 ft.^{2}/day



Load No.= 6
Load= 2.56 ksf
D_0 = 0.0939
D_{90} = 0.0935
D_{100} = 0.0934
T_{90} = 1.35 min.

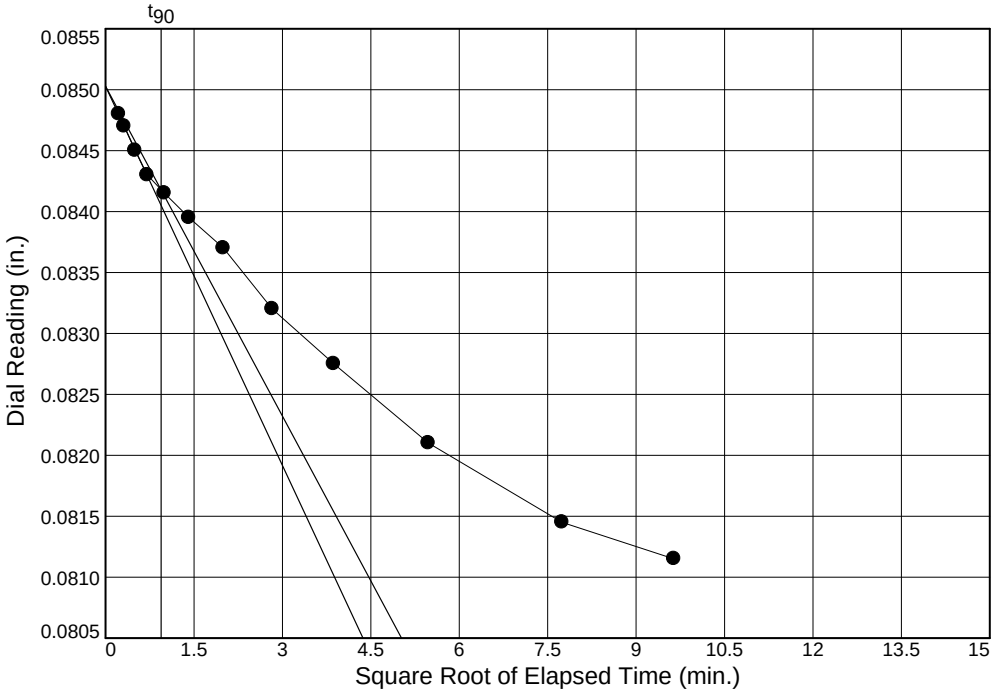
C_v @ T_{90}
0.691 ft.^{2}/day

Figure

Dial Reading vs. Time

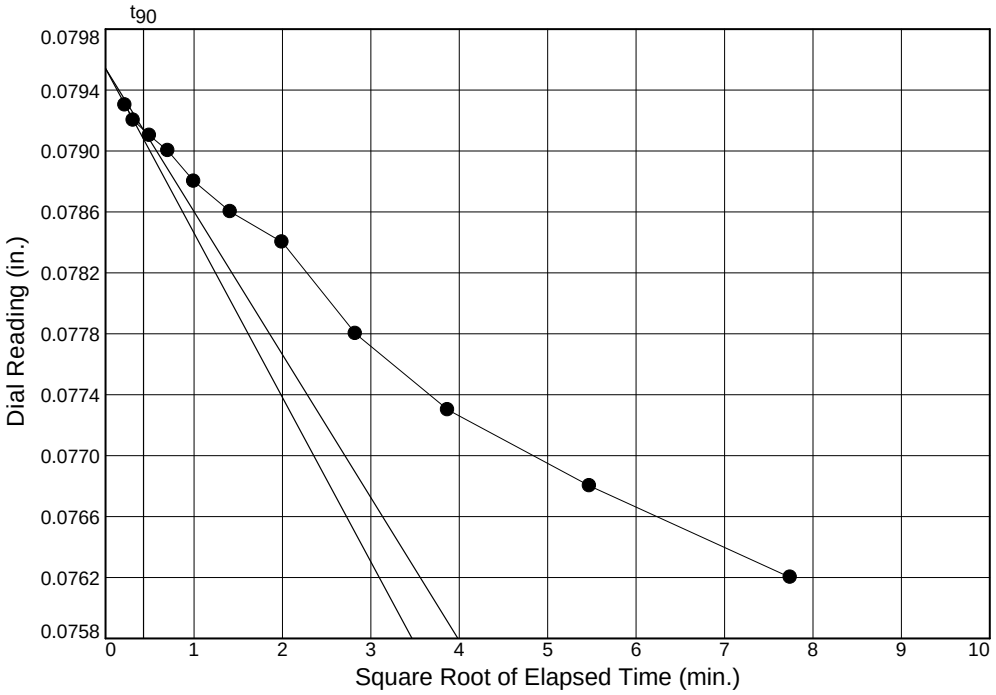
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 9
Load= 0.33 ksf
D_0 = 0.0850
D_{90} = 0.0842
D_{100} = 0.0841
T_{90} = 0.89 min.

C_v @ T_{90}
1.079 ft.^{2}/day



Load No.= 10
Load= 0.10 ksf
D_0 = 0.0795
D_{90} = 0.0791
D_{100} = 0.0791
T_{90} = 0.18 min.

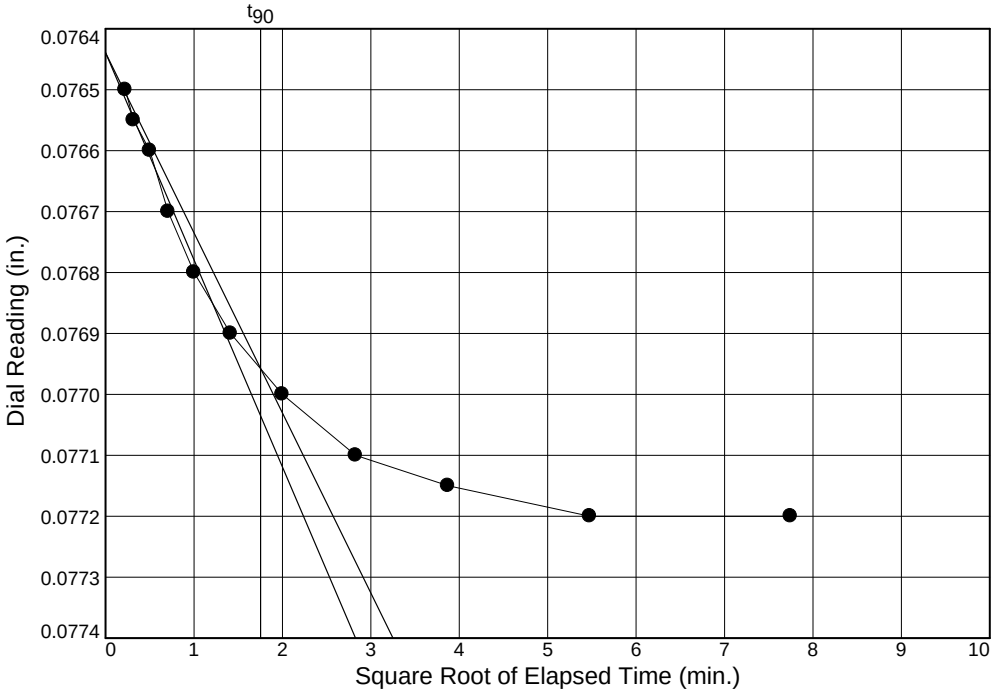
C_v @ T_{90}
5.267 ft.^{2}/day

Figure

Dial Reading vs. Time

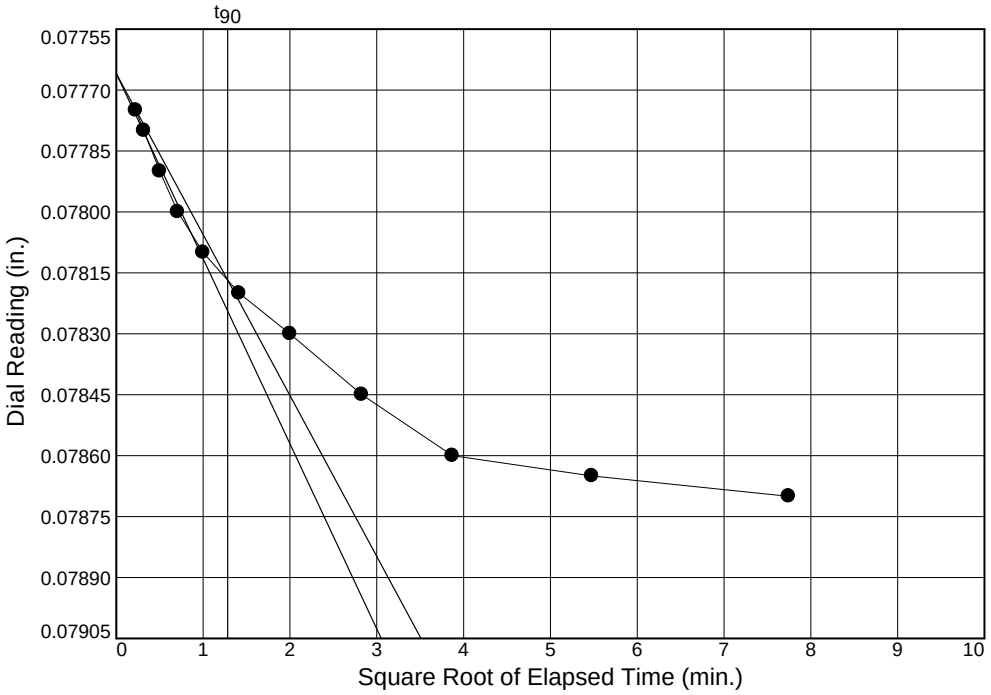
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 11
Load= 0.33 ksf
D_0 = 0.0764
D_{90} = 0.0770
D_{100} = 0.0770
T_{90} = 3.07 min.

C_v @ T_{90}
0.318 ft.^{2}/day



Load No.= 12
Load= 0.62 ksf
D_0 = 0.0777
D_{90} = 0.0782
D_{100} = 0.0782
T_{90} = 1.64 min.

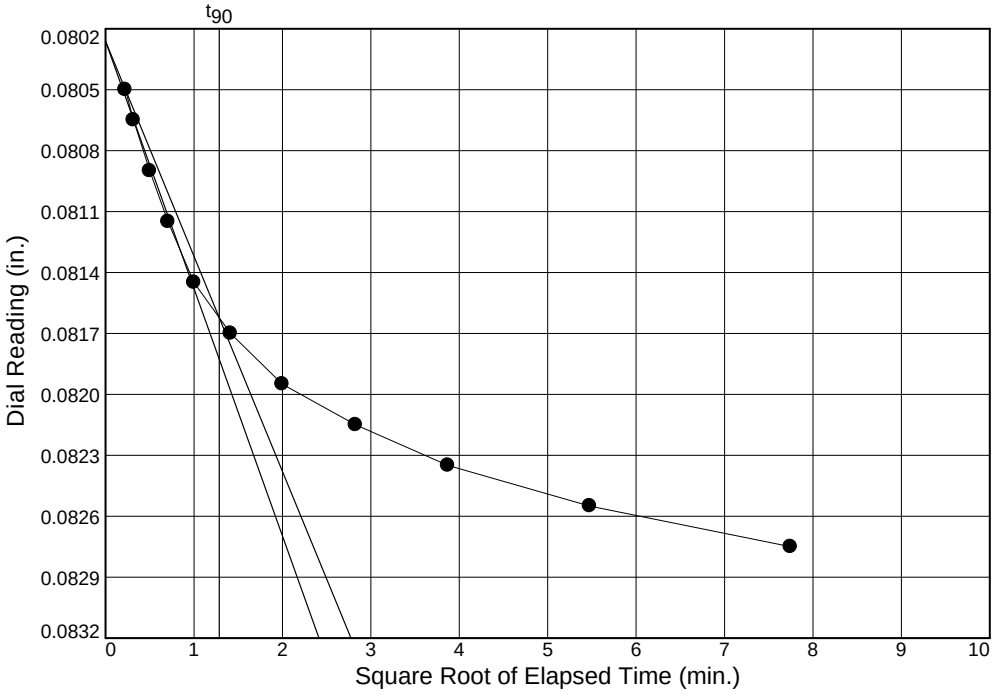
C_v @ T_{90}
0.594 ft.^{2}/day

Figure

Dial Reading vs. Time

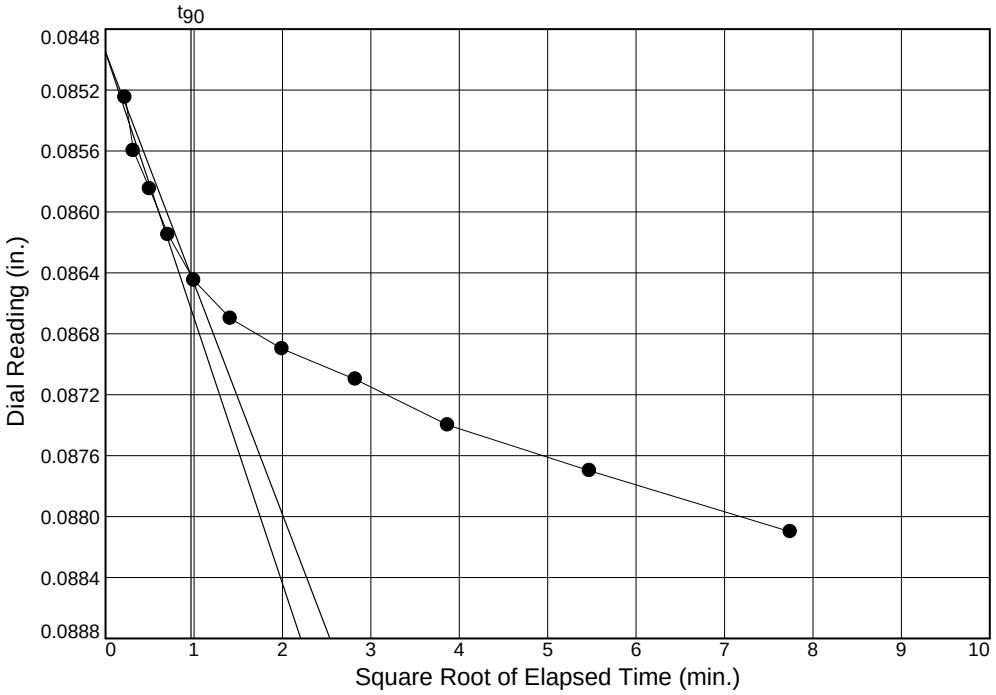
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 13
Load= 1.27 ksf
D_0 = 0.0803
D_{90} = 0.0816
D_{100} = 0.0818
T_{90} = 1.65 min.

C_v @ T_{90}
0.585 ft.^{2}/day



Load No.= 14
Load= 2.56 ksf
D_0 = 0.0850
D_{90} = 0.0864
D_{100} = 0.0866
T_{90} = 0.93 min.

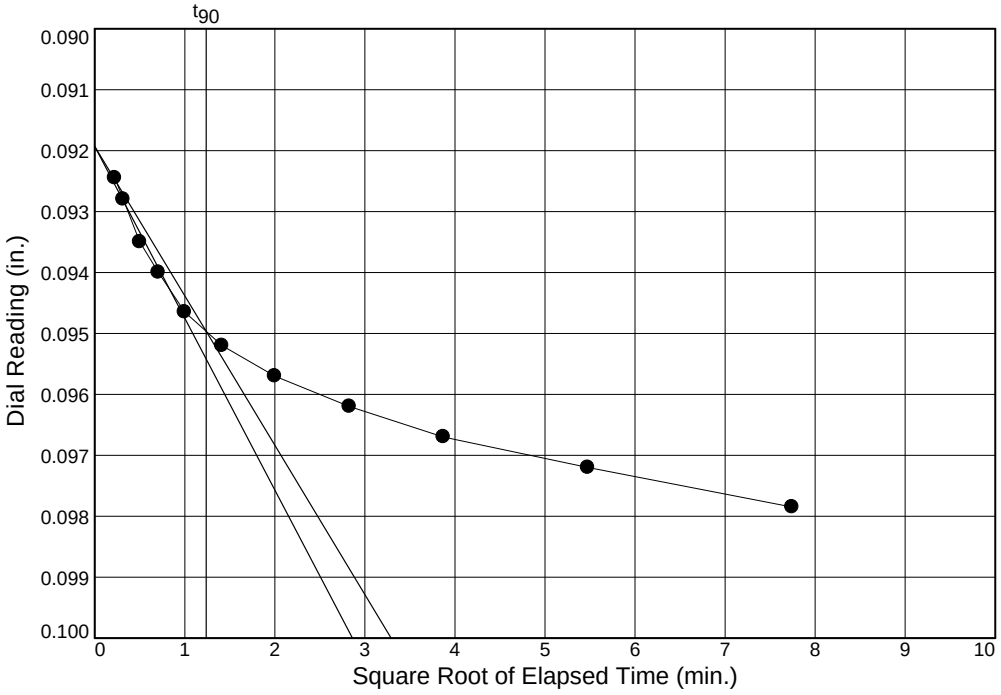
C_v @ T_{90}
1.021 ft.^{2}/day

Figure

Dial Reading vs. Time

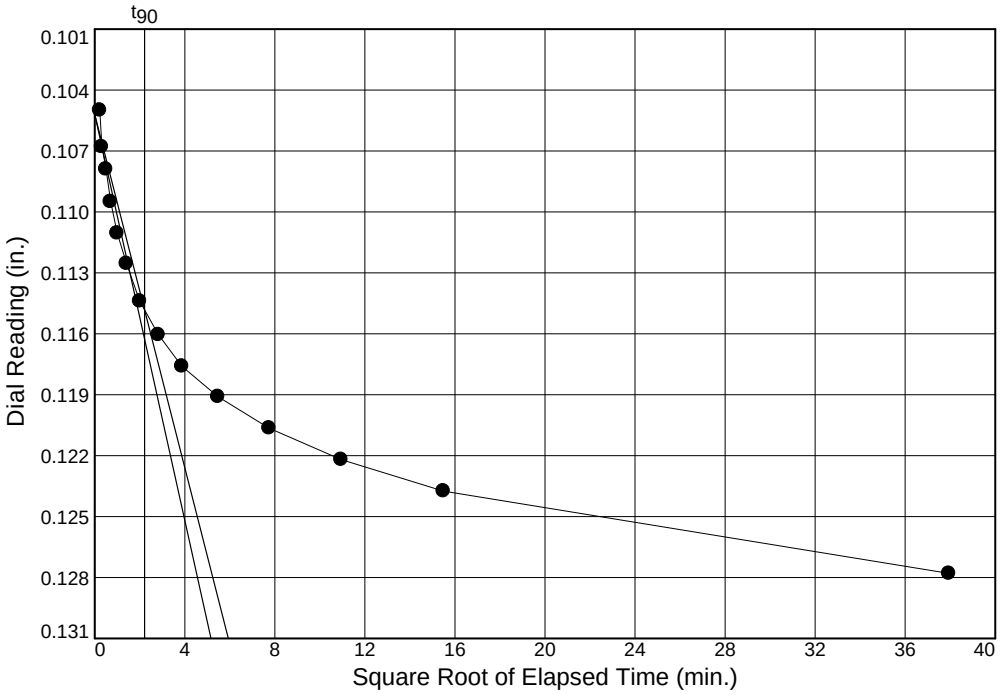
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 15
Load= 5.80 ksf
D_0 = 0.0919
D_{90} = 0.0950
D_{100} = 0.0953
T_{90} = 1.53 min.

C_v @ T_{90}
0.607 ft.^{2}/day



Load No.= 16
Load= 12.27 ksf
D_0 = 0.1052
D_{90} = 0.1148
D_{100} = 0.1159
T_{90} = 4.90 min.

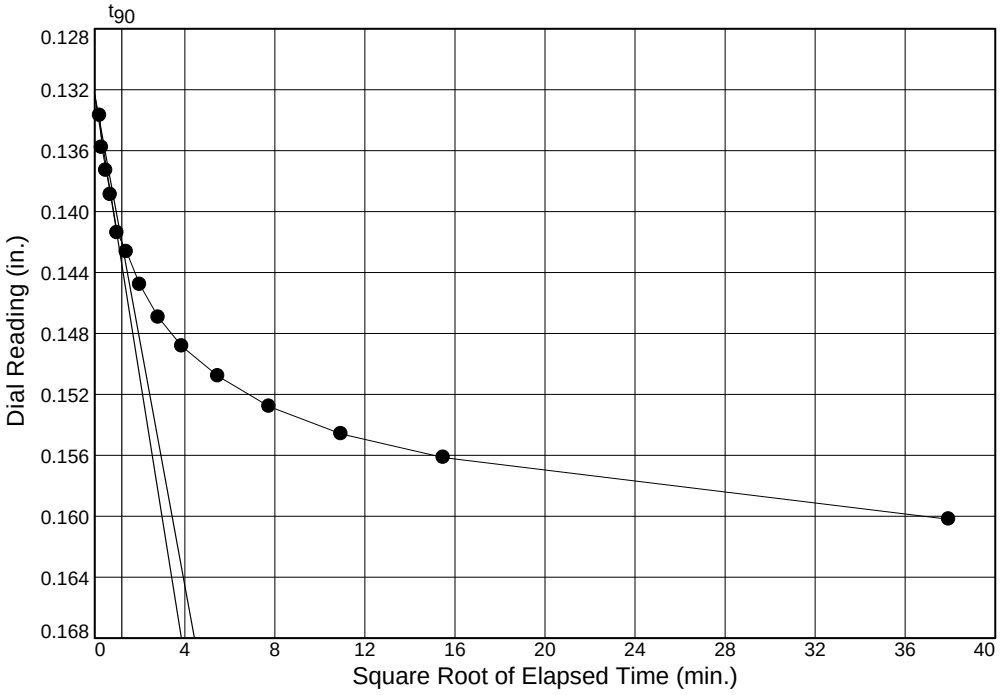
C_v @ T_{90}
0.180 ft.^{2}/day

Figure

Dial Reading vs. Time

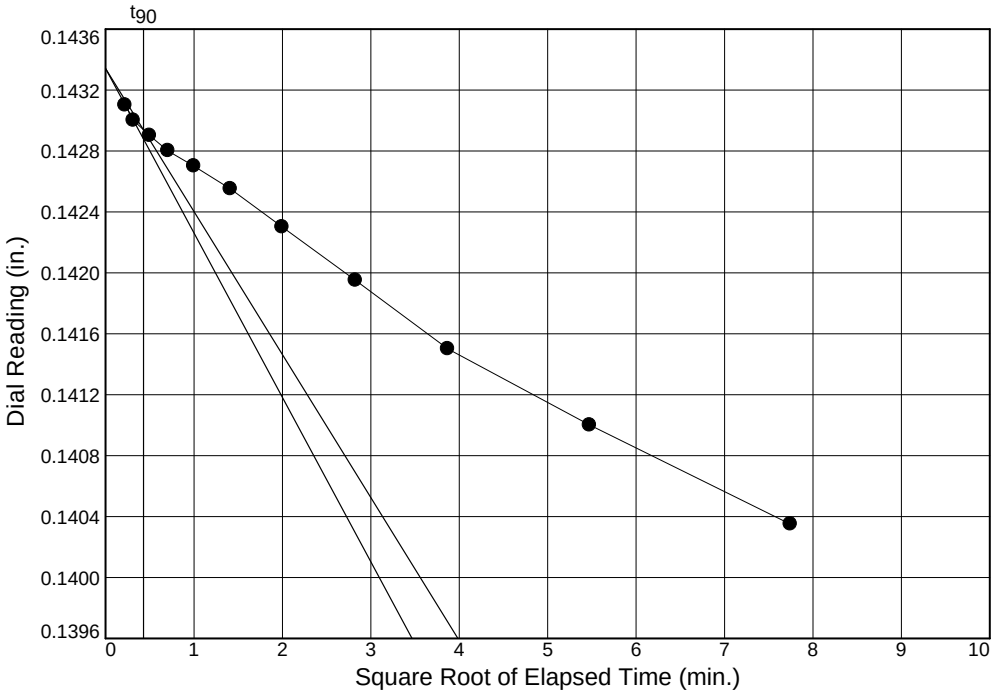
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 17
Load= 25.20 ksf
D_0 = 0.1323
D_{90} = 0.1420
D_{100} = 0.1431
T_{90} = 1.44 min.

C_v @ T_{90}
0.562 ft.^{2}/day



Load No.= 22
Load= 0.62 ksf
D_0 = 0.1433
D_{90} = 0.1429
D_{100} = 0.1429
T_{90} = 0.18 min.

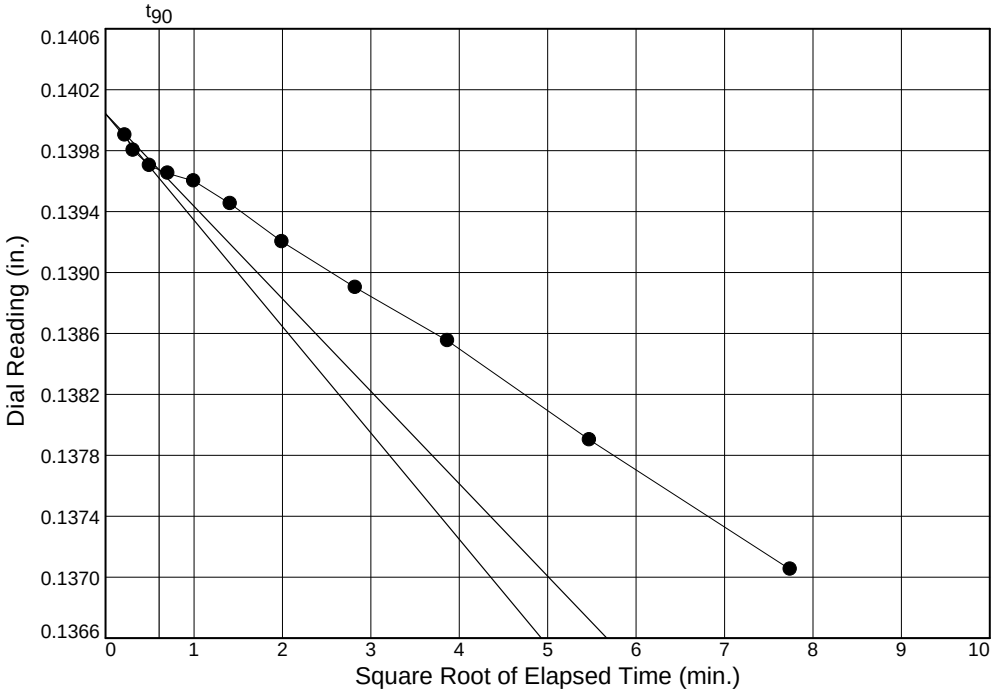
C_v @ T_{90}
4.321 ft.^{2}/day

Figure

Dial Reading vs. Time

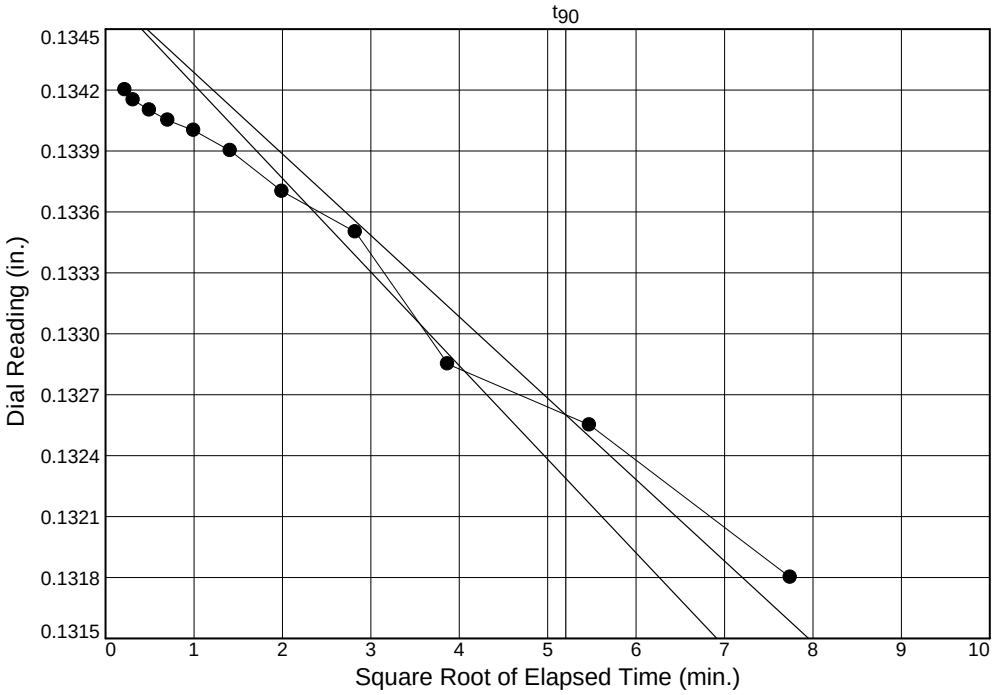
Project No.: 2236031-606
Project: Durham WRRF Phase 6B Digester Preliminary Design

Source of Sample: 9180 Depth: 16.5-18.5' Sample Number: B-02, ST-5



Load No.= 23
Load= 0.33 ksf
D_0 = 0.1400
D_{90} = 0.1397
D_{100} = 0.1396
T_{90} = 0.37 min.

C_v @ T_{90}
2.195 ft.^{2}/day

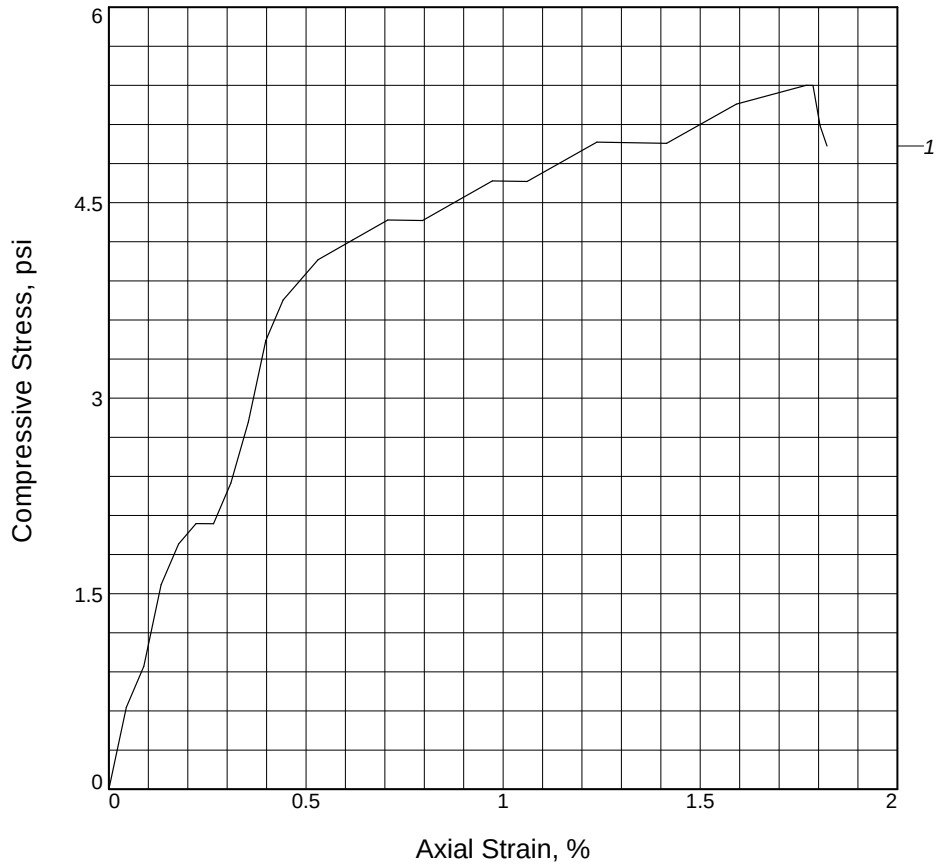


Load No.= 25
Load= 0.10 ksf
D_0 = 0.1347
D_{90} = 0.1326
D_{100} = 0.1324
T_{90} = 27.08 min.

C_v @ T_{90}
0.030 ft.^{2}/day

Figure

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psi	5.40			
Undrained shear strength, psi	2.70			
Failure strain, %	1.8			
Strain rate, %/min.	0.25			
Water content, %	30.5			
Wet density, pcf	122.3			
Dry density, pcf	93.7			
Saturation, %	99.8			
Void ratio	0.8493			
Specimen diameter, in.	2.85			
Specimen height, in.	5.66			
Height/diameter ratio	1.99			

Description:

LL = 41.2	**PL =** 15.0	**PI =** 26.2	**Assumed GS=** 2.775	**Type:**

Project No.: 2236031-606
Date Sampled:
Remarks:

Figure _____

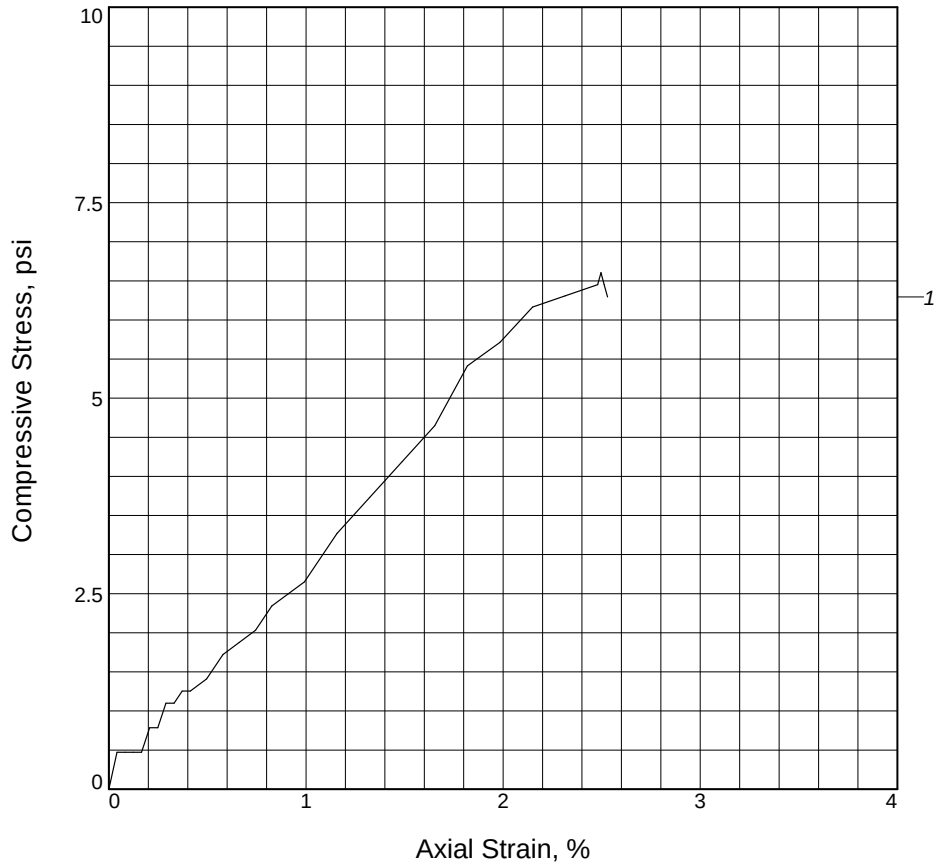
Client: Jacobs

Project: Durham WRRF Phase 6B

Source of Sample: 9180 **Depth:** 46.5-48.5'
Sample Number: B-01, ST-13

UNCONFINED COMPRESSION TEST
FEI Testing & Inspection, Inc.
Corvallis, OR

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psi	6.60			
Undrained shear strength, psi	3.30			
Failure strain, %	2.5			
Strain rate, %/min.	0.25			
Water content, %	31.3			
Wet density, pcf	116.5			
Dry density, pcf	88.7			
Saturation, %	95.9			
Void ratio	0.8648			
Specimen diameter, in.	2.84			
Specimen height, in.	6.05			
Height/diameter ratio	2.13			

Description:

LL = 77.2	**PL =** 52.6	**PI =** 24.6	**Assumed GS=** 2.65	**Type:**

Project No.: 2236031-606
Date Sampled:
Remarks:

Figure _____

Client: Jacobs

Project: Durham WRRF Phase 6B

Source of Sample: 9180 **Depth:** 16.5-18.5'
Sample Number: B-02, ST-5

UNCONFINED COMPRESSION TEST
FEI Testing & Inspection, Inc.
Corvallis, OR

FEI Testing & Inspection, Inc.
Project Name: Durham WRRF Phase 6B Digester Preliminary Design
Project No.: 2236031-606
FEI Sample No. 9180

FEI
TESTING & INSPECTION, INC.
Geotechnical & Construction Services

Shelby Tube Descriptions

BOREHOLE NO.: B-01, ST-13

PROJECT NAME:	Durham WRRF Phase 6B	PROJECT NO.:	2236031-606
SAMPLE:	9180	DEPTH:	46.5-48.5'
DATE SAMPLED:		DATE PUSHED:	09-26-2023
COMMENTS:			

Sample Description	Sample Testing
	0-11" No recovery
	11.0-15.5" Drilling fluid & sluff
	15.5-18.0" Plasticity Index
Dark tan with iron staining, low plasticity silty CLAY	18.0-20.0" Percent Fines
	20.0-26.0" Unconfined Compression

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Geotechnical & Construction Services

Shelby Tube Descriptions

BOREHOLE NO.: B-02, ST-5

PROJECT NAME:	Durham WRRF Phase 6B	PROJECT NO.:	2236031-606
SAMPLE:	9180	DEPTH:	16.5-18.5'
DATE SAMPLED:		DATE PUSHED:	09-26-2023
COMMENTS:			

Sample Description	Sample Testing
	0-13.5" No recovery
	13.5-15.5" Drilling fluid & sluff
	15.5-17.0" Plasticity Index
Dark brown, high plasticity, clayey SILT	17.0-18.0" Percent Fines
	18.0-19.0" Consolidation
	19.0-25.0" Unconfined Compression

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Geotechnical & Construction Services

Shelby Tube Descriptions

BOREHOLE NO.: B-02, ST-13

PROJECT NAME:	Durham WRRF Phase 6B	PROJECT NO.:	2236031-606
SAMPLE:	9180	DEPTH:	46.5-48.8'
DATE SAMPLED:		DATE PUSHED:	09-26-2023
COMMENTS:			

Sample Description	Sample Testing
	0-20.5" No recovery
	20.5-22.0" Sluff
	22.0-23.5" Percent fines
	23.5-25.5" Plasticity Index
Brown coarse SAND	

Appendix E
Previous Investigation Data

Appendix E.1
2011 Durham Advanced Wastewater Treatment Facility Cogeneration and Brown Grease Receiving Facilities Project

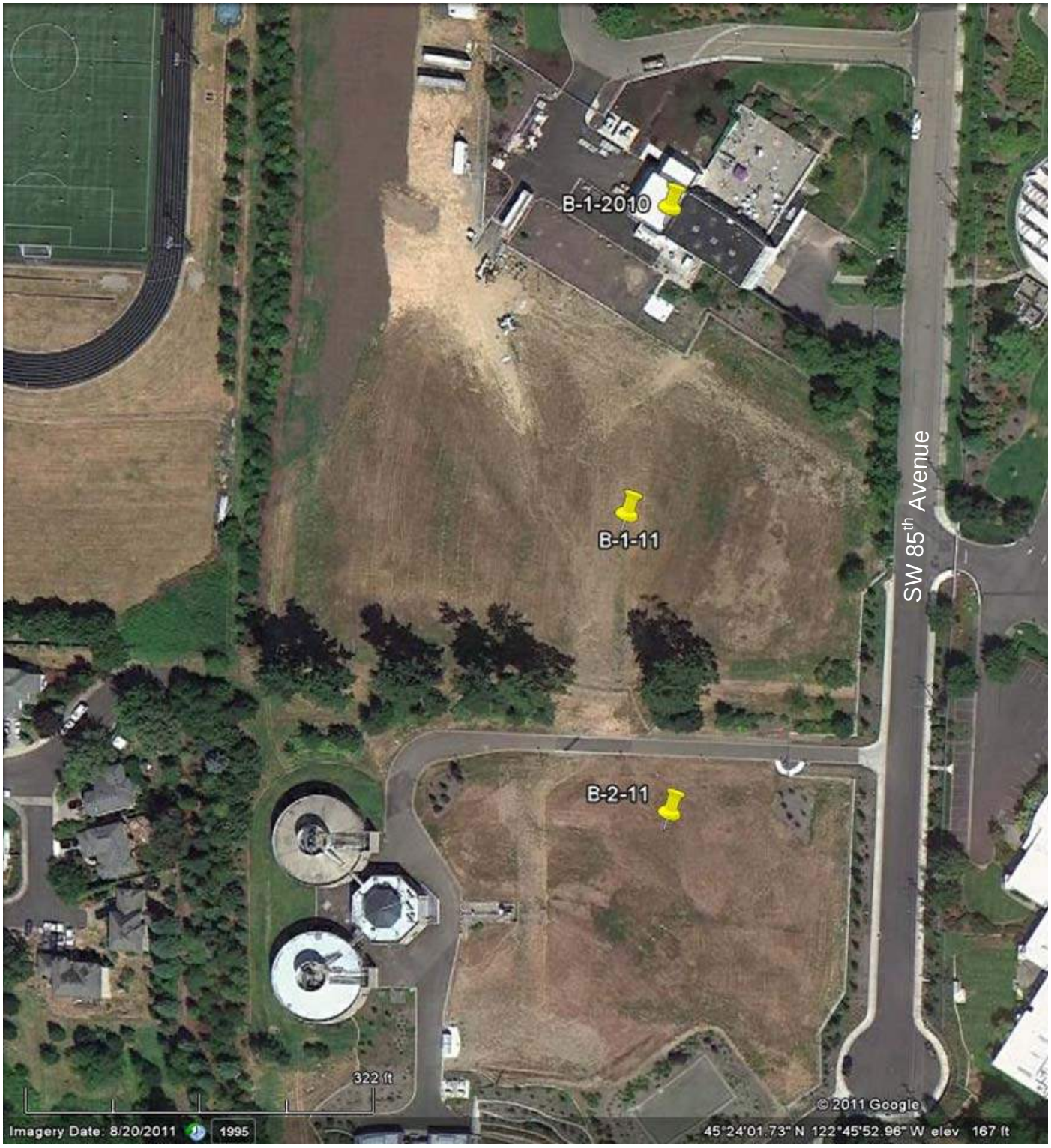

Figure 2-1
Map of Boring Locations
Clean Water Services – Preliminary Design For The Durham AWWTF Cogeneration and Brown Grease Receiving Facilities
Tigard, Oregon
(Figure was created using a map from Google Earth)

PROJECT NUMBER:	BORING NUMBER:
422389.03.31.30	B-1-11 SHEET 1 OF 2

SOIL BORING LOG

PROJECT : Clean Water Services Durham WWTP, Tigard, OR LOCATION : Future Cogeneration Facility

ELEVATION : DRILLING CONTRACTOR : Western States Soil Conservation, Hubbard, OR (James Dennis)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill Rig with 140-Pound Autohammer, Mud Rotary, Spade Bit

WATER LEVELS : --- START : 10/14/11 11:00 END : 10/14/11 15:00 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.1				Grass at the ground surface.	
						Driller reports soft drilling conditions for most of the hole.
	2.5 - 4.0	1.4	1-SS	5-5-6 (11)	**Silty SAND (SM)** brown, moist, medium dense, fine grained sand, 31 percent fines.	WC = 29% P200 = 31%
5						
	5.0 - 6.5	1.2	2-SS	5-5-4 (9)	**Silty SAND (SM)** brown, moist, loose, fine grained sand, estimated 15 to 25 percent fines.	
10						
	10.0 - 11.5	1.2	3-SS	4-5-4 (9)	**Poorly graded SAND with silt (SP-SM)** brown, moist, loose, fine grained sand, estimated 5 to 15 percent fines.	
15						
	15.0 - 16.5	1.3	4-SS	4-5-6 (11)	**Poorly graded SAND with silt (SP-SM)** brown, moist, medium dense, fine grained sand, estimated 10 to 15 percent fines.	
20						
	20.0 - 21.5	1.3	5-SS	7-8-7 (15)	**Poorly graded SAND with silt (SP-SM)** dark brown, moist to wet, medium dense, fine to medium grained sand with trace coarse grained sand, estimated 5 to 15 percent fines. Layered appearance - layers alternate every 2 to 3 inches, with the layers having slightly different colors and gradations.	
						Driller reports feeling a thin lens of gravel at 23'.
25						
	25.0 - 26.5	1.4	6-SS	9-8-7 (15)	**Poorly graded SAND with silt (SP-SM)** brown to dark brown, wet, medium dense, fine grained sand, estimated 5 to 15 percent fines. One inch thick lenses of Silty SAND (SM) at 25.8' and 26.1'.	
						Driller reports denser drilling at 28'. Coarse sand and fine gravel are coming up in the cuttings.
30						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
422389.03.31.30	B-1-11	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : Clean Water Services Durham WWTP, Tigard, OR LOCATION : Future Cogeneration Facility

ELEVATION : DRILLING CONTRACTOR : Western States Soil Conservation, Hubbard, OR (James Dennis)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill Rig with 140-Pound Autohammer, Mud Rotary, Spade Bit

WATER LEVELS : --- START : 10/14/11 11:00 END : 10/14/11 15:00 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 - 31.5	1.5	7-SS	8-10-14 (24)	**30.0-31.0': Silty SAND to clayey SAND (SM/SC)** gray, wet, medium dense, fine grained sand, estimated 15 to 25 percent fines. **31.0-31.5': Clayey SAND (SC)** gray, moist, medium dense, fine grained sand, 34 percent low to medium plasticity fines.	30.0-31.0': 7-SSA 31.0-31.5': 7-SSB PP = >4.5 tsf WC = 23% P200 = 34% Driller reports feeling a sticky clay-like material from 31' to 35'.
35						
	35.0 - 36.5	1.5	8-SS	8-16-22 (38)	**Silty SAND (SM)** Highly weathered rock / residual soil that has weathered into sand and silt. Brown, orange, gray, dark brown, reddish brown, moist, dense, fine to coarse grained sand, estimated 15 to 25 percent low plasticity fines.	
40						
	40.0 - 41.5	1.5	9-SS	12-11-12 (23)	**Sandy SILT (ML)** tan with orange mottling, moist, very stiff, low plasticity, 40 percent fine grained sand with trace medium and coarse grained sand.	PP = 1.5, 2.5 tsf TV = 0.5 tsf WC = 33% P200 = 60%
45						
	45.0 - 46.5	1.5	10-SS	10-10-10 (20)	**Silty SAND (SM)** tan and orange mottled, moist, medium dense, predominantly fine grained sand with trace medium and coarse grained sand, estimated 30 to 40 percent low plasticity fines.	PP = 1.25, 1.5 tsf TV = 0.3 tsf
50						
	50.0 - 51.5	1.5	11-SS	2-4-3 (7)	**Sandy Elastic SILT (MH)** gray, moist, firm, high plasticity, 44 percent fine grained sand with trace medium and coarse grained sand that appeared to be pieces of weathered rock.	PP = <0.25 tsf WC = 45%, LL = 57%, PL = 25%, PI = 32% P200 = 56%
	51.5 - 53.5	2.0	12-ST	push	**Sandy Elastic SILT (MH)** Same as 11-SS at top of tube. **Sandy SILT (ML)** Same as 13-SS at bottom of tube.	Sample 12-ST pushed at 100, 200, 300, 500 psi for each 6-inch increment. PP = 2.75, 2.75 tsf TV = 0.5 tsf
	53.5 - 55.0	1.5	13-SS	5-10-16 (26)	**Sandy SILT (ML)** gray with dark brown mottling, moist, very stiff, low plasticity, estimated 40 to 50 percent fine grained sand with trace medium to coarse grained sand that appeared to be pieces of weathered rock.	
55						End of hole at 55.0'. Backfilled hole with bentonite chips. Disposed of drilling cuttings onsite.
60						

PROJECT NUMBER:	BORING NUMBER:
422389.03.31.30	B-2-11 SHEET 1 OF 2

SOIL BORING LOG

PROJECT : Clean Water Services Durham WWTP, Tigard, OR LOCATION : Future Brown Grease Facility

ELEVATION : DRILLING CONTRACTOR : Western States Soil Conservation, Hubbard, OR (James Dennis)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill Rig with 140-Pound Autohammer, Mud Rotary, Spade Bit

WATER LEVELS : --- START : 10/14/11 08:00 END : 10/14/11 10:00 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.1				Grass at the ground surface.	Driller reports feeling scattered gravel from 0' to 5'.
	2.5 - 4.0	1.2	1-SS	6-5-5 (10)	**Silty SAND (SM)** brown, moist, loose, fine grained sand, estimated 30 to 40 percent non-plastic fines. (FILL)	
5						
	5.0 - 6.5	1.4	2-SS	5-7-11 (18)	**Silty SAND (SM)** brown and gray, moist, medium dense, fine to medium grained sand, estimated 25 to 35 percent non-plastic fines. Layered appearance - layer colors alternate between brown and gray every 2 to 3 inches. (FILL)	
10						
	10.0 - 11.5	1.2	3-SS	2-3-3 (6)	**Silty SAND (SM)** brown, moist, loose, fine grained sand, estimated 25 to 35 percent non-plastic fines, contains dark brown inclusions, has a slightly jumbled appearance. (FILL)	
15						
	15.0 - 16.5	1.1	4-SS	3-3-5 (8)	**Poorly graded SAND with silt (SP-SM)** gray, moist, loose, fine grained sand, estimated 5 to 10 percent fines.	
20						
	20.0 - 21.5	1.4	5-SS	8-11-12 (23)	**Poorly graded SAND with silt (SP-SM)** gray, moist, medium dense, fine to medium grained sand with trace coarse grained sand, estimated 5 to 10 percent fines.	Driller reports feeling a several inch thick layer of gravel at 21'.
25						
	25.0 - 26.5	1.4	6-SS	12-12-11 (23)	**Poorly graded SAND with silt (SP-SM)** gray, moist, medium dense, fine to medium grained sand, estimated 5 to 10 percent fines.	Driller reports feeling scattered gravel from 25' to 27'. Driller reports denser and smoother drilling from 27' to 40'.
30						

PROJECT NUMBER:	BORING NUMBER:
422389.03.31.30	B-2-11 SHEET 2 OF 2

SOIL BORING LOG

PROJECT : Clean Water Services Durham WWTP, Tigard, OR LOCATION : Future Brown Grease Facility

ELEVATION : DRILLING CONTRACTOR : Western States Soil Conservation, Hubbard, OR (James Dennis)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill Rig with 140-Pound Autohammer, Mud Rotary, Spade Bit

WATER LEVELS : --- START : 10/14/11 08:00 END : 10/14/11 10:00 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 - 31.5	1.3	7-SS	11-10-11 (21)	**30.0-30.3': Poorly graded SAND with silt (SP-SM)** gray, wet, medium dense, fine to medium grained sand, estimated 5 to 10 percent fines. **30.3-31.3': Silty SAND (SM)** brown, moist, medium dense, fine grained sand, estimated 20 to 30 percent fines.	30.0-30.3': 7-SSA 30.3-31.3': 7-SSB
35	35.0 - 36.5	1.5	8-SS	13-13-17 (30)	**Poorly graded SAND (SP)** gray, brown, reddish brown, orange, yellow, moist, medium dense, fine to coarse grained sand, estimated less than 5 percent fines.	
40	40.0 - 41.5	1.3	9-SS	17-17-17 (34)	**Poorly graded SAND (SP)** gray, moist, dense, fine to medium grained sand, estimated less than 5 percent fines.	
45						End of hole at 41.5'. Backfilled hole with bentonite chips. Disposed of drilling cuttings onsite.
50						
55						
60						

Northwest Testing, Inc.
A Division of Northwest Geotech, Inc.
9120 SW Pioneer Court, Suite B • Wilsonville, Oregon 97070 503/682-1880 FAX: 503/682-2753

TECHNICAL REPORT

Report To:	Ms. Heike Shipton CH2M HILL 2020 SW Fourth Avenue, Suite 300 Portland, Oregon 97201	**Date:** **Lab No.:**	11/11/11 11-287
Project:	Laboratory Testing – 422389.03.31.30 Durham Clean Water Services	**Project No.:**	2139.1.1

Report of: Moisture content, Atterberg limits and amount of material passing the No. 200 sieve

Sample Identification

As requested, NTI determined the moisture content, Atterberg limits, and amount of material passing the No. 200 sieve on samples delivered to our laboratory on November 8, 2011 by a CH2M HILL representative. All testing was performed in general accordance with the methods indicated. Our laboratory's test results are summarized on the following tables.

Laboratory Test Results

Atterberg Limits (ASTM D 4318)			
Sample ID	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**
B-1-11 11-SS @ 50-51.5 ft.	57	25	32

Moisture Content of Soil (ASTM D 2216)			
Sample ID	**Moisture Content (Percent)**	**Sample ID**	**Moisture Content (Percent)**
B-1-11 1-SS @ 2.5-4.0 ft.	29.1	B-1-11 9-SS @ 40-41.5 ft.	33.3
B-1-11 7-SSB @ 31-31.5 ft.	23.4	B-1-11 11-SS @ 50-51.5 ft.	45.4

Amount of Material Finer than the No. 200 Sieve (ASTM D1140)		
Sample ID	**Moisture Content (%)**	**Percent Passing the No. 200 Sieve**
B-1-11 1-SS @ 2.5-4.0 ft.	29.1	30.6
B-1-11 7-SSB @ 31-31.5 ft.	23.4	34.1
B-1-11 9-SS @ 40-41.5 ft.	33.3	60.0
B-1-11 11-SS @ 50-51.5 ft.	45.4	55.5

Copies: Addressee

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Appendix E.2
2010 Clean Water Services Durham Wastewater Treatment Plant Phase 5B1 Project

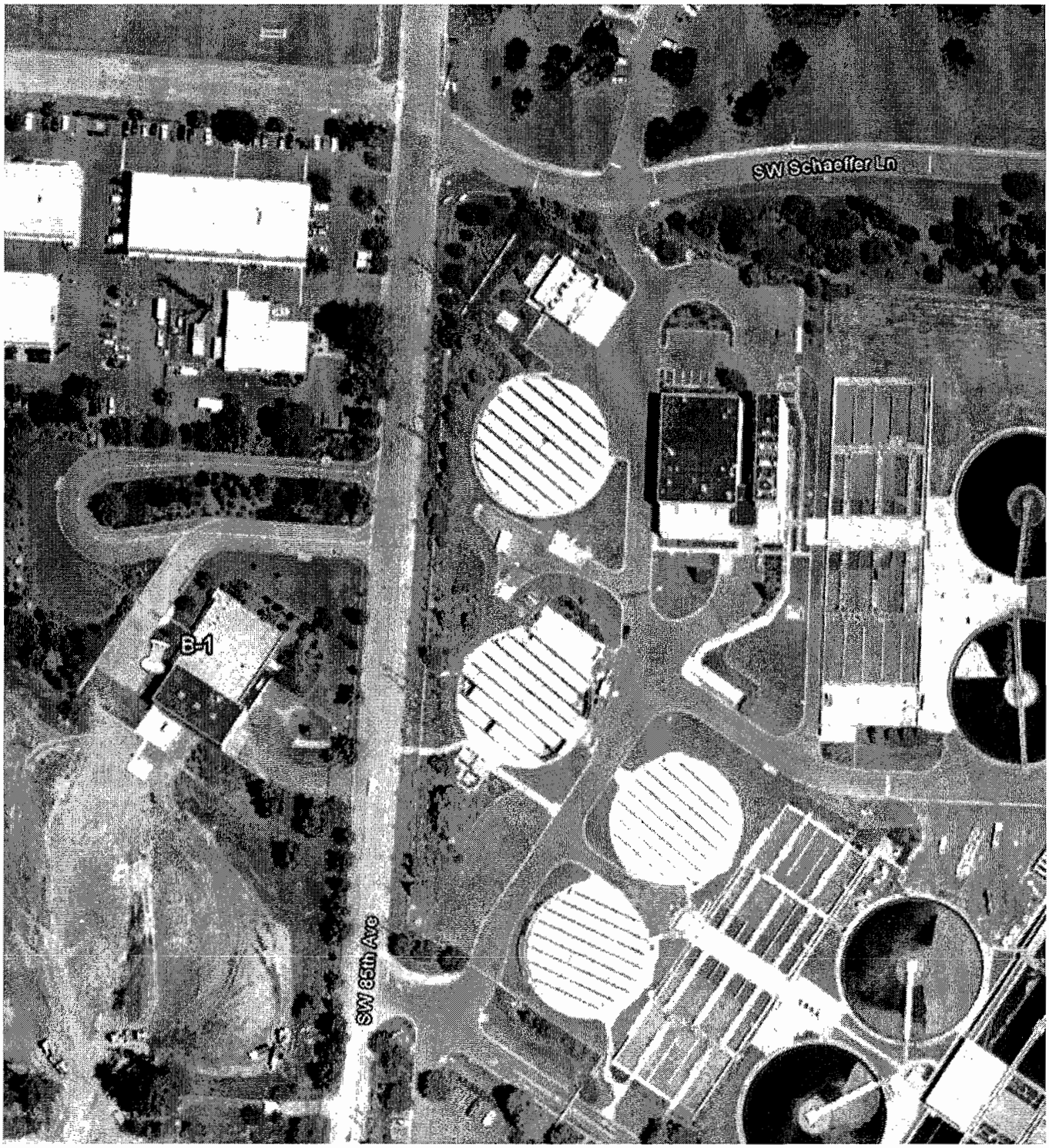


Figure 1
Map of Boring Location
Durham Wastewater Treatment Plant Upgrade Project – Phase 5B1
(Figure was created using a Google Earth map)

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
..	SHEET 1 OF 1

BORING LOG EXPLANATION

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT :

WATER LEVELS : --- START : END : LOGGER :

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"(-6") (N)	SOIL DESCRIPTION	COMMENTS
					SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	1.0				Sample Interval: Top/Bottom (ft. bgs) Amount of Sample Recovered (ft)	Comments Comments and observations regarding drilling or sampling made by the driller or field personnel.
	2.5	1.5				
	3.5				Sample Type - Sample Number	Field and Laboratory tests include the following:
5	5.0		1-SS		(SS) Standard split-spoon drive sampler, 2.0-inch (51-mm) outside diameter, 1.4-inch (35-mm) inside diameter (without liners)	WC Moisture Content (ASTM D-2216)
					(MC) Modified California split-spoon drive sampler, 3.0-inch (76-mm) outside diameter, 2.4-inch (64-mm) inside diameter (with liners)	UWD Dry Unit Weight (ASTM D-2937) in pounds per cubic foot (pcf) or kilonewtons per cubic meter (kN/m3)
10					(ST) Thin-walled Shelby tube sampler, 3.0-inch (76-mm) outside diameter, 2.9-inch (74-mm) inside diameter	SA Sieve analysis (ASTM D-422) See appropriate laboratory data sheets for gradation curve
					(OT) Thin-walled Shelby tube sampler (Osterberg), 3.0-inch (76-mm) outside diameter 2.9-inch (74-mm) inside diameter	P200 Percentage of soil particles passing the No. 200 sieve (ASTM D-1140)
					(G) Grab sample collected from drill cuttings	HD Standard hydrometer analysis
					(BU) Bucket sample collected from test pits	LL Atterberg Limits (ASTM D-4318) PL LL = Liquid Limit, PL = Plastic Limit, PI PI = Plasticity Index
15	15.0				Standard Penetration Test Results	COMP-S Compaction Test Standard Proctor (ASTM D-698)
	16.5			3-5-6(-4) (11)	Number of blows required to advance driven sampler over three (or four) 6-inch (152-mm) increments. Number in parenthesis is the total number of blows required to advance the sampler 12-inch (305 mm) beyond the first 6-inch (152-mm) interval. Drive samplers advanced using a 140 lb (63.5 kg) Hammer with the 30-inch (762-mm) drop. The blow counts given have not been modified to account for field and/or depth conditions.	COMP-M Compaction Test Modified Proctor (ASTM D-1557)
						PP Unconfined Compressive Strength in tons per square foot (tsf) or kilopascals (kPa) measured using a pocket penetrometer device
20						TV Unconfined Compressive Strength in tsf or kPa measured using a torvane device
					General Notes	TX-UU Unconsolidated Undrained Triaxial Shear Strength in pounds per square foot (psf) or kPa as measured in the laboratory (ASTM D-2850). Confining pressure given in parenthesis
					1) Soil classifications are based on the Unified Soil Classification System. Classifications and descriptions made in the field have been modified based on the results of laboratory testing.	TX-CU Consolidated Undrained Triaxial Shear Strength in psf or kPa as measured in the laboratory (ASTM D-4767). Confining pressure given in parenthesis
25					2) Boring logs depict subsurface conditions only at the specific locations and times the boring was made. Logs do not necessarily reflect strata variations that may exist between boring locations.	CONSOL One-Dimensional Consolidation (ASTM D-2435)
						OC Organic content (ASTM D-2974)
30						CA Corrosion Analysis

TABLE 1
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

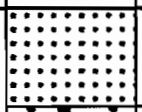
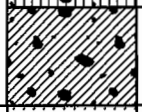
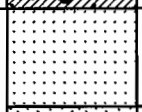
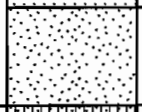
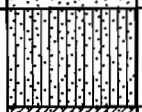
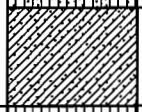
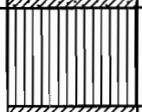
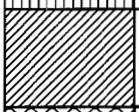
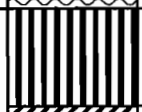
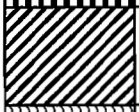
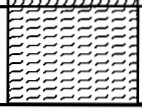
TABLE 2
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with 1/2-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with 1/2-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with 1/2-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with 1/2-in. steel rod driven with 5-lb hammer
>50	Very Dense	Penetrated only a few inches with 1/2-in. steel rod driven with 5-lb hammer

TABLE 3
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily Penetrated several inches by fist
2-4	Soft	0.25-0.50	<0.12-0.25	Easily Penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.50	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.50-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

USCS CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND-CLAY MIXTURES
	SAND AND SANDY SOILS (MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

CH2MHILL

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
391538.B1.05.GT	B-1 SHEET 1 OF 3

SOIL BORING LOG

PROJECT : CWS Durham WWTP Phase 5B1, Tigard, OR LOCATION : 6 Feet NW of Existing Headworks Bldg

ELEVATION : 180.0 ft NAVD88 DRILLING CONTRACTOR : Hardcore Drilling, Inc. (Steve VanBergen)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill rig with 140 Pound Autohammer, Mud Rotary

WATER LEVELS : 21.5 ft below ground surface START : 1/8/10 10:30 END : 1/8/10 14:30 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	1.0				Asphalt pavement at the ground surface.	Driller reports asphalt is 5 inches thick; underlain by baserock to 1 feet below ground surface (bgs).
	2.5	0.9	1-SS	11-8-7 (15)	**1.0 - 1.5': Poorly graded SAND with silt and gravel (SP-SM)** brown, wet, medium dense, fine to coarse grained sand, estimated 15 percent gravel, estimated 10 to 15 percent fines. **1.5 - 1.9': Silty SAND (SM)** brown and gray, moist, medium dense, fine grained, estimated 25 to 35 percent fines, contained several 0.5-inch diameter wood chunks.	1.0 - 1.5': Sample 1-SSA 1.5 - 1.6': Sample 1-SSB
	4.0	1.2	2-SS	4-3-3 (6)	**Silty SAND (SM)** brown, wet, loose, fine grained, estimated 20 to 30 percent fines, micaceous	
5	5.5	1.0	3-SS	5-2-3 (5)	**Silty SAND (SM)** similar to 2-SS, except trace subangular gravel and several small wood chunks that were approximately 1/8 inch in diameter.	
	7.0	1.4	4-SS	6-4-4 (8)	**Silty SAND (SM)** similar to 2-SS, except trace iron oxide staining.	
	8.5	1.3	5-SS	4-3-2 (5)	**Silty SAND (SM)** similar to 2-SS, except the material at the very bottom of the sampler was wetter and softer.	
10	10.0	1.0	6-SS	3-1-11 (12)	**8.5 - 9.0': Silty SAND (SM)** similar to 2-SS, excpet medium dense. **9.0 - 9.5': Poorly graded SAND with silt and gravel (SP-SM)** gray, wet, medium dense, fine to coarse grained sand, estimated 15 percent fines, estimated 15 percent subangular gravel.	8.5 - 9.0': Sample 6-SSA 9.0 - 9.5': Sample 6-SSB
	11.5	1.1	7-SS	11-15-16 (31)	**Poorly graded SAND with silt and gravel (SP-SM)** similar to 6-SSB, except dense, fine to coarse subangular sand, estimated 30 to 40 percent subangular gravel, estimated 5 to 10 percent fines, contained signs of weathering (some orange and red coloring and slightly cemented).	
	13.0	1.3	8-SS	18-12-17 (29)	**Poorly graded SAND with silt and gravel (SP-SM)** similar to 7-SS, except medium dense.	
	14.5	1.0	9-SS	15-20-19 (39)	**Poorly graded GRAVEL with silt and sand (GP-GM)** grayish brown, wet, dense, subangular gravel up to 1 inch in diameter, estimated 35 to 40 percent fine to coarse grained sand, estimated 5 to 10 percent fines, contains trace amounts of orange and red staining that appear to be from weathering.	Sample 9-SS had slightly more gravel than Sample 7-SS, but the material looked very similar and appeared to have the same geologic origin.
15						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
391538.B1.05.GT	B-1	SHEET 2 OF 3

SOIL BORING LOG

PROJECT : CWS Durham WWTP Phase 5B1, Tigard, OR LOCATION : 6 Feet NW of Existing Headworks Bldg

ELEVATION : 180.0 ft NAVD88 DRILLING CONTRACTOR : Hardcore Drilling, Inc. (Steve VanBergen)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill rig with 140 Pound Autohammer, Mud Rotary

WATER LEVELS : 21.5 ft below ground surface START : 1/8/10 10:30 END : 1/8/10 14:30 LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	17.5					
	19.0	0.8	10-SS	8-9-7 (16)	**Poorly graded SAND with silt and gravel (SP-SM)** grayish brown, wet, medium dense, fine to coarse grained sand, estimated 20 to 30 percent subrounded to subangular gravel (with some red staining), estimated 5 to 10 percent fines.	
20	20.0					
	21.5	0.1	11-SS	5-3-3 (6)	**Silty SAND with gravel (SM)** grayish brown, wet, loose, mostly fine grained with trace medium to coarse grained sand, estimated 15 to 25 percent fines, estimated 15 percent subangular gravel.	Driller reported softer soil at 20 feet, so drilling was paused so that a sample could be taken. Due to limited recovery in Sample 11-SS, the driller advanced an oversized sampler over the same interval to gain more recovery (Sample 12-OS, blowcounts: 6-4-10). The sample description is based on the material recovered in the oversized sampler.
	22.5					
	24.0	0.8	13-SS	4-2-6 (8)	**22.5 - 22.9': Silty SAND with gravel (SM)** same as 12-OS. **22.9 - 23.3': Silty SAND (SM)** brown and gray, wet, loose, fine grained, estimated 15 to 25 percent fines.	22.5 - 22.9': Sample 13-SSA 22.9 - 23.3': Sample 13-SSB The material recovered in 13-SSB came mostly from the sampler shoe. The material was mixed together as it was pried out of the shoe, but it appeared that there may have been thin layers of gray and brown soil.
25	25.0					
	26.5	0.9	14-SS	9-11-12 (23)	**Poorly graded SAND with silt (SP-SM)** gray, wet, medium dense, fine grained, estimated 5 percent fines. 1 inch lens at 25.1 and 25.7 feet of slightly lighter gray material that had an estimated 5 to 10 percent fines.	It appears that the soil above approximately 20 feet is fill material and the soil below 23 feet is native material.
30						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
391538.B1.05.GT	B-1 SHEET 3 OF 3

SOIL BORING LOG

PROJECT : CWS Durham WWTP Phase 5B1, Tigard, OR

LOCATION : 6 Feet NW of Existing Headworks Bldg

ELEVATION : 180.0 ft NAVD88

DRILLING CONTRACTOR : Hardcore Drilling, Inc. (Steve VanBergen)

DRILLING METHOD AND EQUIPMENT : Truck Mounted CME 75 Drill rig with 140 Pound Autohammer, Mud Rotary

WATER LEVELS : 21.5 ft below ground surface

START : 1/8/10 10:30

END : 1/8/10 14:30

LOGGER : R. Lawrence

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
30.0						
	30.0	0.9	15-SS	14-10-10 (20)	**30.0 - 30.6': Poorly graded SAND (SP)** gray, wet, medium dense, fine grained, estimated less than 5 percent fines. **30.6 - 30.9': Poorly graded SAND with silt and gravel (SP-SM)** gray, wet, medium dense, estimated 10 to 15 percent fines, several pieces of subangular gravel up to 1 inch in diameter (estimated 15 percent gravel).	30.0 - 30.6': Sample 15-SSA 30.6 - 30.9': Sample 15-SSB
31.5						End of hole at 31.5 feet. After drilling was completed, driller baled out all of the water and drilling mud from the hole. During the span of approximately 20 minutes, the water in the hole rose to approximately 21.5 feet. Abandoned the hole in accordance with OAR 690-240. Backfilled the hole with 6 bags of bentonite chips.
35						
40						
45						

Appendix E.3
2003 Durham Facility Phase 4 Expansion Project

Plot Date: 08-APR-2005 18:02
User: kxkal
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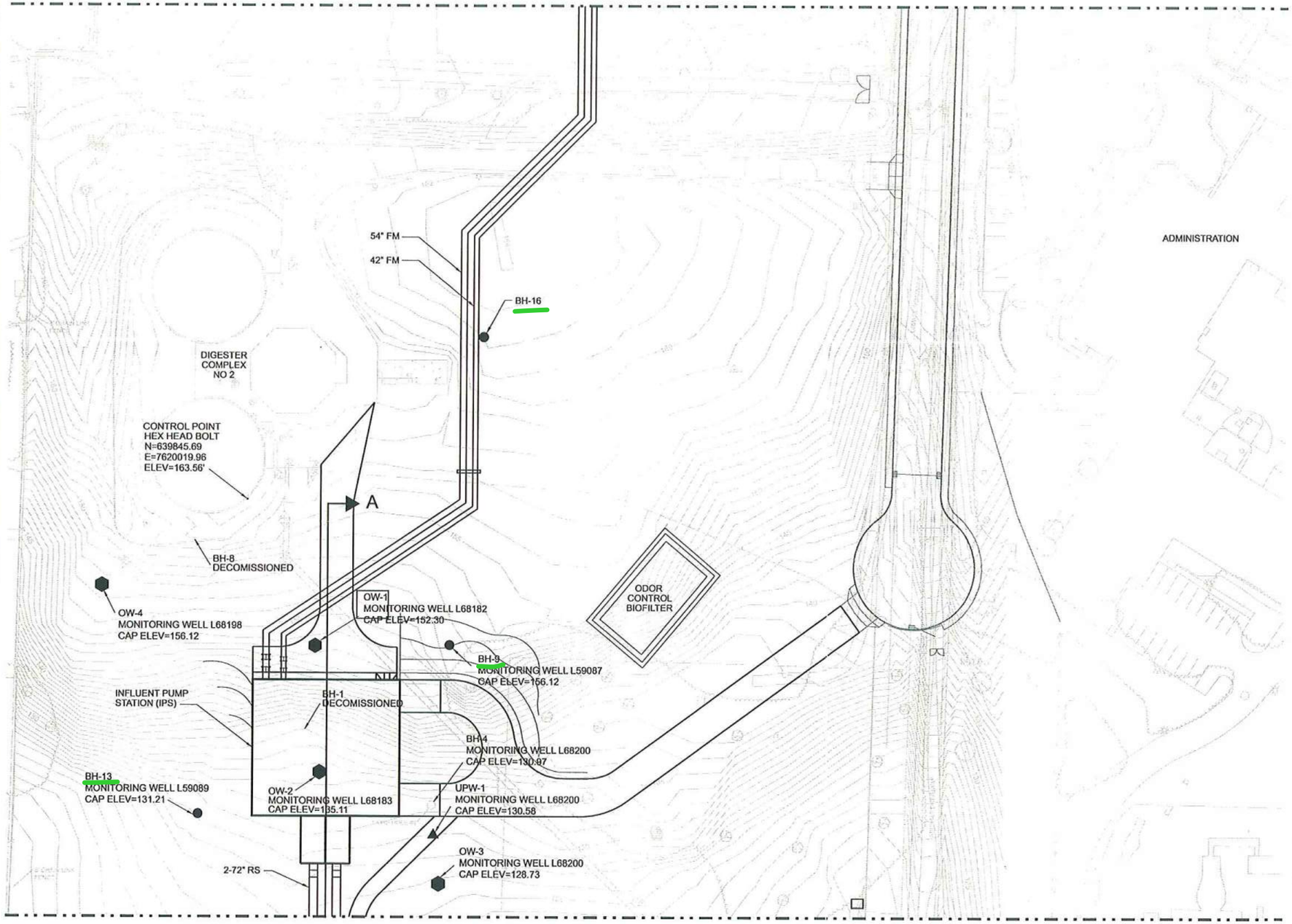
Job No: 1530575

MATCHLINE GEO DATA-2



GEOTECHNICAL LEGEND

TP-1:	DEEP TEST PITS
OW-1:	OBSERVATION WELLS (GEOPROBES)
UPW-1:	PUMP TEST EXTRACTION WELL
BH-1:	EXISTING PHASE 3 BORINGS
BH-9:	PHASE 4 BORINGS
	SECTION LINES

MATCHLINE GEO DATA-4

REV	DATE	BY	DESCRIPTION

SCALE: 1" = 40'

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED JLJ
DRAWN DRH
CHECKED AHR

SUBMITTED BY
(PROJECT MANAGER'S NAME) LICENSE NO. DATE
(COMPANY OFFICER'S NAME) LICENSE NO. DATE

MWH IN ASSOCIATION WITH: SQUIER ASSOCIATES - ENSR INTERNATIONAL ARCHITECTS ASSOCIATIVE INC

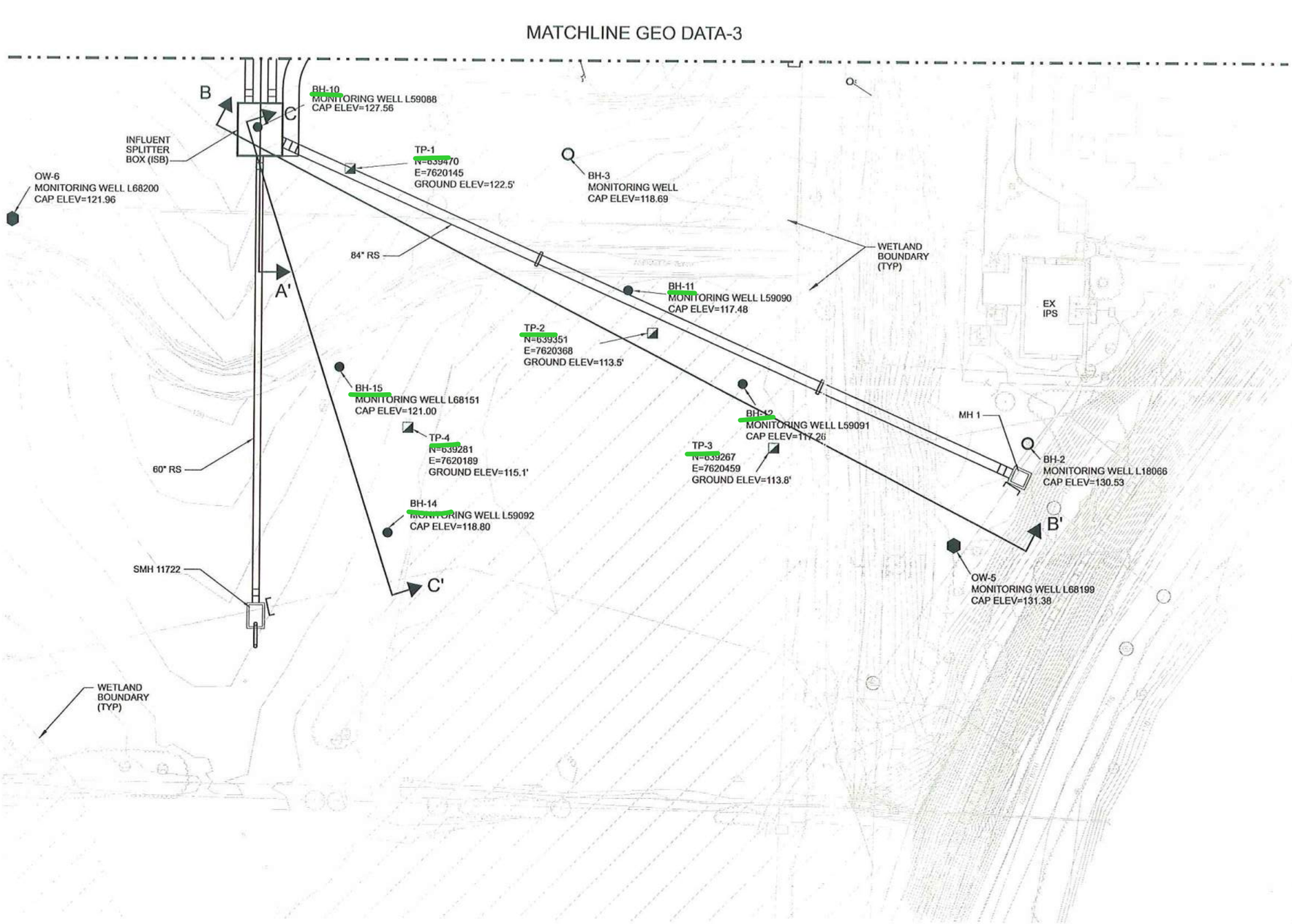
CleanWater Services — Our commitment is clear.

DURHAM FACILITY PHASE 4 EXPANSION

GEOTECHNICAL
EXPLORATION LOCATIONS PLAN 2

SHEET: OF
DWG: GEO DATA-3
DATE: 1/2005
PROJECT NO.: 4969

MATCHLINE GEO DATA-3



GEOTECHNICAL LEGEND

- TP-1: DEEP TEST PITS
- OW-1: OBSERVATION WELLS (GEOPROBES)
- UPW-1: PUMP TEST EXTRACTION WELL
- BH-1: EXISTING PHASE 3 BORINGS
- BH-9: PHASE 4 BORINGS
- SECTION LINES

Plot Date: 08-APR-2005 18:03
User: lokai
File: N:\Projects\Clean_Water_Services\Durham_Facility_IPS\Design\Geotech\geo-data-4.dgn
Job No: 1530575

REV	DATE	BY	DESCRIPTION

SCALE: 1" = 40'

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED: JLJ
DRAWN: DRH
CHECKED: AHR

SUBMITTED BY
(PROJECT MANAGER'S NAME) LICENSE NO. DATE
(COMPANY OFFICER'S NAME) LICENSE NO. DATE

MWH IN ASSOCIATION WITH: SQUIER ASSOCIATES - ENSR INTERNATIONAL ARCHITECTS ASSOCIATIVE INC

CleanWater Services — Our commitment is clear.

DURHAM FACILITY
PHASE 4 EXPANSION

GEOTECHNICAL
EXPLORATION LOCATIONS
PLAN 3

SHEET: OF
DWG: GEO DATA-4
DATE: 1/2005
PROJECT NO.: 4969

Table A1
Terminology Used to Describe Soil

Soil Descriptions

Soils exist in mixtures with varying proportions of components. The predominant soil, i.e., greater than 50 percent based upon total dry weight, is the primary soil type and is capitalized in our log descriptions, e.g., SAND, GRAVEL, SILT or CLAY. Lesser percentages of other constituents in the soil mixture are indicated by use of modifier words in general accordance with the Visual-Manual Procedure (ASTM D2488-93). "General Accordance" means that certain local and common descriptive practices have been followed. In accordance with ASTM D2488, group symbols (such as GP or CH) are applied on that portion of the soil passing the 3-inch (75mm) sieve based upon visual examination. The following describes the use of soil names and modifying terms used to describe fine- and coarse-grained soils.

Fine - Grained Soils (More than 50% fines passing 0.074 mm, #200 sieve)
The primary soil type, i.e. SILT or CLAY is designated through visual – manual procedures to evaluate soil toughness, dilatency, dry strength, and plasticity. The following describes the terminology used to describe fine - grained soils, and varies from ASTM 2488 terminology in the use of some common terms.

Primary soil NAME, adjective and symbols			Plasticity Description	Plasticity Index (PI)
		ORGANIC		
SILT	**CLAY**	**SILT & CLAY**		
ML & MH	CL & CH	OL & OH		
SILT		Organic SILT	Non-plastic	0 - 3
SILT		Organic SILT	Low plasticity	4 - 10
Clayey SILT	Silty CLAY	Organic clayey SILT	Medium Plasticity	>10 – 20
Clayey SILT	CLAY	Organic silty CLAY	High Plasticity	>20 – 40
Clayey SILT	CLAY	Organic CLAY	Very Plastic	>40

Modifying terms describing secondary constituents, estimated to 5 percent increments, are applied as follows:

Description	% Composition
Trace sand, trace gravel	5% - 10%
With sand; with gravel	15% - 25%
Sandy, or gravelly	30% - 45%

Borderline Symbols, for example CH/MH, are used where soils are not distinctly in one category or where variable soil units contain more than one soil type. **Dual Symbols**, for example CL-ML, are used where two symbols are required in accordance with ASTM D2488.

Soil Consistency. Consistency terms are applied to fine-grained, plastic soils (i.e., PI $\geq$ 4). Descriptive terms are based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84, as follows.

Consistency Term	SPT N-value	Unconfined Compressive Strength Tons/sq.ft.	kPa
Very soft	Less than 2	Less than 0.25	Less than 24
Soft	2 - 4	0.25 - 0.5	24 - 48
Medium stiff	5 - 8	0.5 - 1.0	48 – 96
Stiff	9 - 15	1.0 - 2.0	96 – 192
Very stiff	16 - 30	2.0 - 4.0	192 – 383
Hard	Over 30	Over 4.0	Over 383

Note: For SILT with low to non-plastic behavior, (i.e., PI < 4) a relative density description is applied.

Table A1 *(Continued)*
Terminology Used to Describe Soil

Coarse - Grained Soils (less than 50% fines)

Coarse-grained soil descriptions, i.e., SAND or GRAVEL, are based on that portion of materials passing a 3-inch (75mm) sieve. Coarse-grained soil group symbols are applied in accordance with ASTM D2488 based upon the degree of grading, or distribution of grain sizes of the soil. For example, well graded sand containing a wide range of grain sizes is designated SW; poorly graded gravel, GP, contains high percentages of only certain grain sizes. Terms applied to grain sizes follow.

	Particle Diameter	
	Inches	Millimeters
Sand (S)	0.003 - 0.19	0.075 - 4.8
Gravel (G)	0.19 - 3.0	4.8 - 75
	Additional Constituents	
Cobble	3.0 - 12	75 - 300
Boulder	12 - 120	300 - 3050
Rock Block	>120	>3050

The primary soil type is capitalized, and the amount of fines in the soil are described as indicated by the following examples. Other soil mixtures will provide similar descriptive names.

Example: Coarse-Grained Soil Descriptions with Fines

5% fines	10% fines (Dual Symbols)	15% to 45% fines
GRAVEL with trace silt: GW or GP	GRAVEL with silt, GW-GM	Silty GRAVEL: GM
SAND with trace clay: SW or SP	SAND with clay, SP-SC	Silty SAND: SM

Additional descriptive terminology applied to coarse-grained soils follow.

Coarse-Grained Soil Containing Secondary Constituents

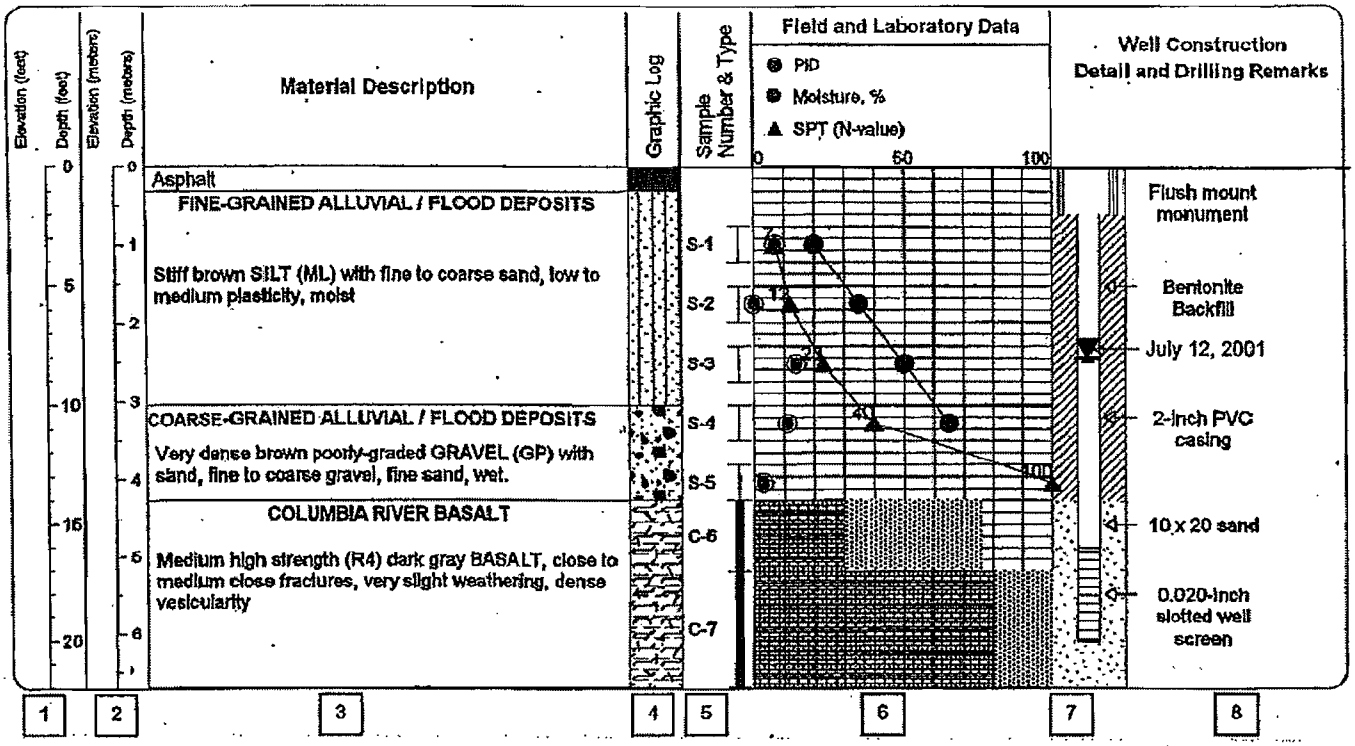
Clean	< 5% fines
With sand or with gravel	15% - 25% sand or gravel
Sandy or gravelly	30% - 45% sand or gravel
With cobbles; with boulders	Any amount cobbles or boulders. Additional terms may be used to describe amount including abundant, scattered.

Cobble and boulder deposits may include a description of the matrix soils, as defined above.

Relative Density terms are applied to granular, non-plastic soils based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84.

Relative Density Term	SPT N-value
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	> 50

TABLE A1



LOG COLUMN DESCRIPTIONS

1 Elevation: Elevation (metric and english) referenced to project datum. .

2 Depth: Distance (metric and english) below the ground surface.

3 Material Description: Description of subsurface soil and rock material encountered. Division lines between deposits are based on field observations and changes in recovered material. Solid lines depict boundaries between units described in the report. Dashed and dotted lines represent changes in lithology within an individual unit. Changes may be gradual in nature or occur over a longer interval than indicated on the log.

Soil classifications are based on the Visual-Manual Procedure, ASTM D2488 and include moisture, color, and relative density/consistency. Soil and rock descriptions in the boring logs are based upon field classifications, modified as appropriate by laboratory classification tests.

4 Graphic Log: Graphic depiction of subsurface material encountered (refer, Sheet 2).

5 Sample Number: Sample Type: Sample identification number. Type of sample collected at depth interval shown (refer, Sheet 2).

6 Field and Laboratory Data: Graphical presentation of field and laboratory data (refer, Sheet 2).

SPT (N-Value): Standard Penetration Test (SPT) N-Value is the number of blows required to drive a standard (2.0-inch) split-spoon sampler a distance of 1 foot using a 140-lb. hammer, dropped 30 inches (ASTM D 1586), and adjusted for type of hammer, see text.

Core Recovery: The total length of core recovered in the core barrel expressed as a percentage of the length of the sampled interval. Rock Quality Designation (RQD) is graphically portrayed for each core run.

7 Well Construction: Graphic depiction of well construction.

8 Remarks: Comments on well construction materials and observations regarding drilling and sampling activities. Dates for water level readings.

DURHAM A.W.W.T.P. PHASE 4
DURHAM, OREGON

BORING LOG LEGEND

SQUIER ASSOCIATES

FIGURE A1
Sheet 1 of 2

= 2.0" O.D. Split Spoon Sample
= 3.0" O.D. Split Spoon Sample
= 3.0" O.D. Thin-Walled Shelby Sample
= Grab Sample
= Ground Water Level When Drilled
= Approximate Static Water Level with Date Measured
= Core Barrel Sample

Shear Strength, T.S.F. (approx.)
Torvane
Pocket Penetrometer

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

Standard Penetration Resistance, Blows per Foot
Natural Water Content, %
Photoionization Detector (PID)
Rock Quality Designation (RQD)
Core Recovery

TYPICAL SOIL SYMBOL DEFINITIONS

Surficial Materials

Pavement section
Fill materials
Fill materials with graphic symbol
Topsoil

Coarse-grained Soils

GRAVEL with sand (SP) and cobbles/boulders
GRAVEL with sand (GP)
GRAVEL with sand, silt (GP/GM), and cobbles/boulders
Silty GRAVEL with sand (GM)
Silty GRAVEL with sand and cobbles
Poorly graded SAND (SP)
Poorly graded SAND with gravel (SP)
Poorly graded SAND with silt (SP/SM)
Silty SAND with gravel (SM)
Silty SAND (SM)

Fine-grained Soils

SILT (ML)
SILT with sand (ML)
SILT (MH)
Organic SILT / SILT with organics (OL, ML/OL)
Sandy CLAY (CL)
CLAY (CL or CH)
Sandy SILT (ML)

Bedrock Units

Weathered BASALT bedrock
BASALT Bedrock
SILTSTONE/CLAYSTONE

TYPICAL WELL SYMBOL DEFINITIONS

Flush monument set in concrete.
Bentonite seal, well casing shown where applicable.
Filter pack, well casing shown where applicable.
Transducer cable in bentonite seal.
Vibrating-wire transducer in sand filter
Grout seal, inclinometer shown
Filter pack, slotted casing shown where applicable.

Stratigraphic Boundaries

Primary Unit Boundary
Internal Material Boundary
Minor or Gradational Material Boundary

Note: Statigraphic and material boundaries shown on boring logs may reflect changes in lithology or material that are gradual in nature or occur over a greater interval than reflected on the log.

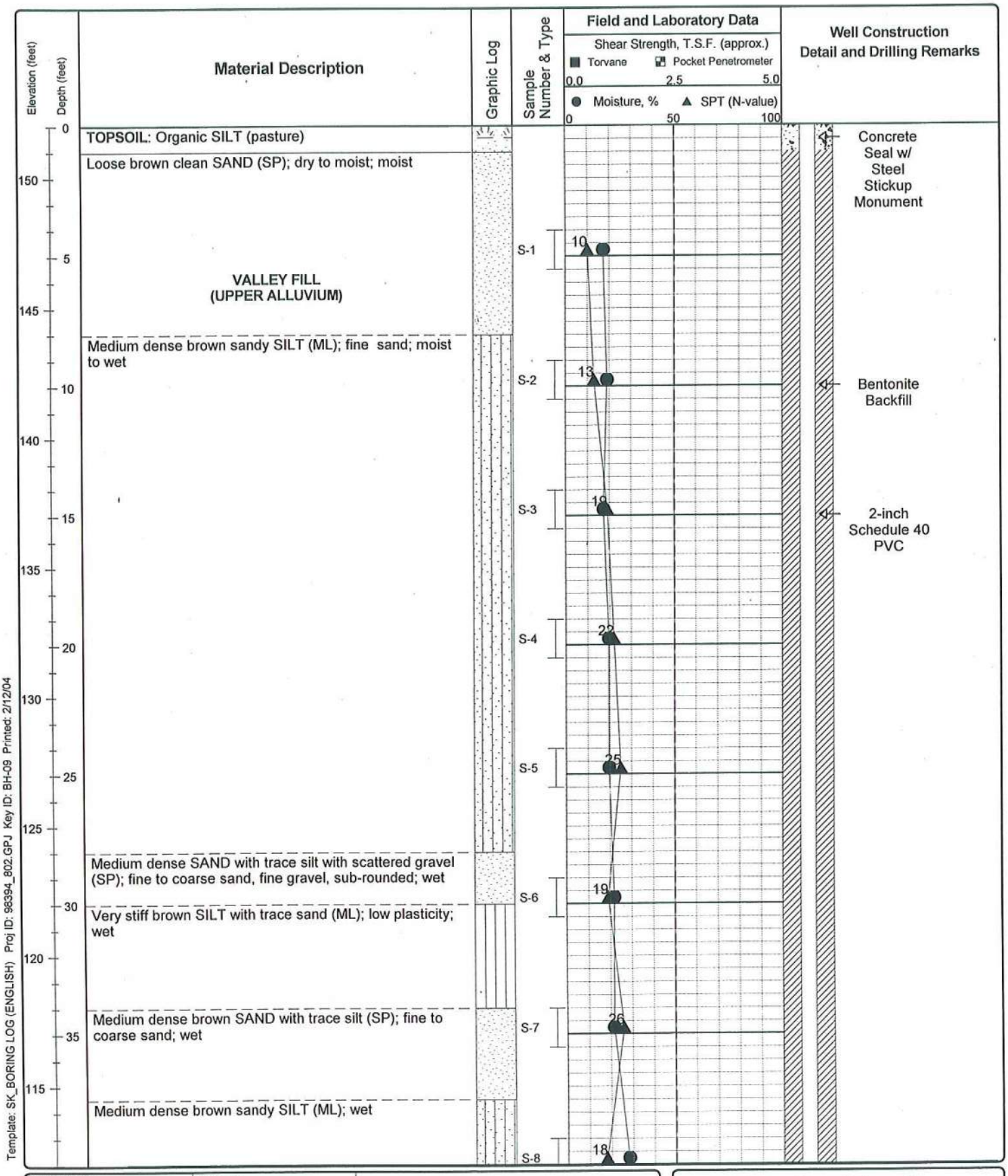
DURHAM A.W.W.T.P. PHASE 4
DURHAM, OREGON

BORING LOG LEGEND

SQUIER ASSOCIATES

FIGURE A1

Sheet 2 of 2



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-09 Printed: 2/12/04

Date Drilling Started	8/25/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	111.5	Station:	Offset:
Surface Elevation (ft)	152.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639738.9 E 7620169.1

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

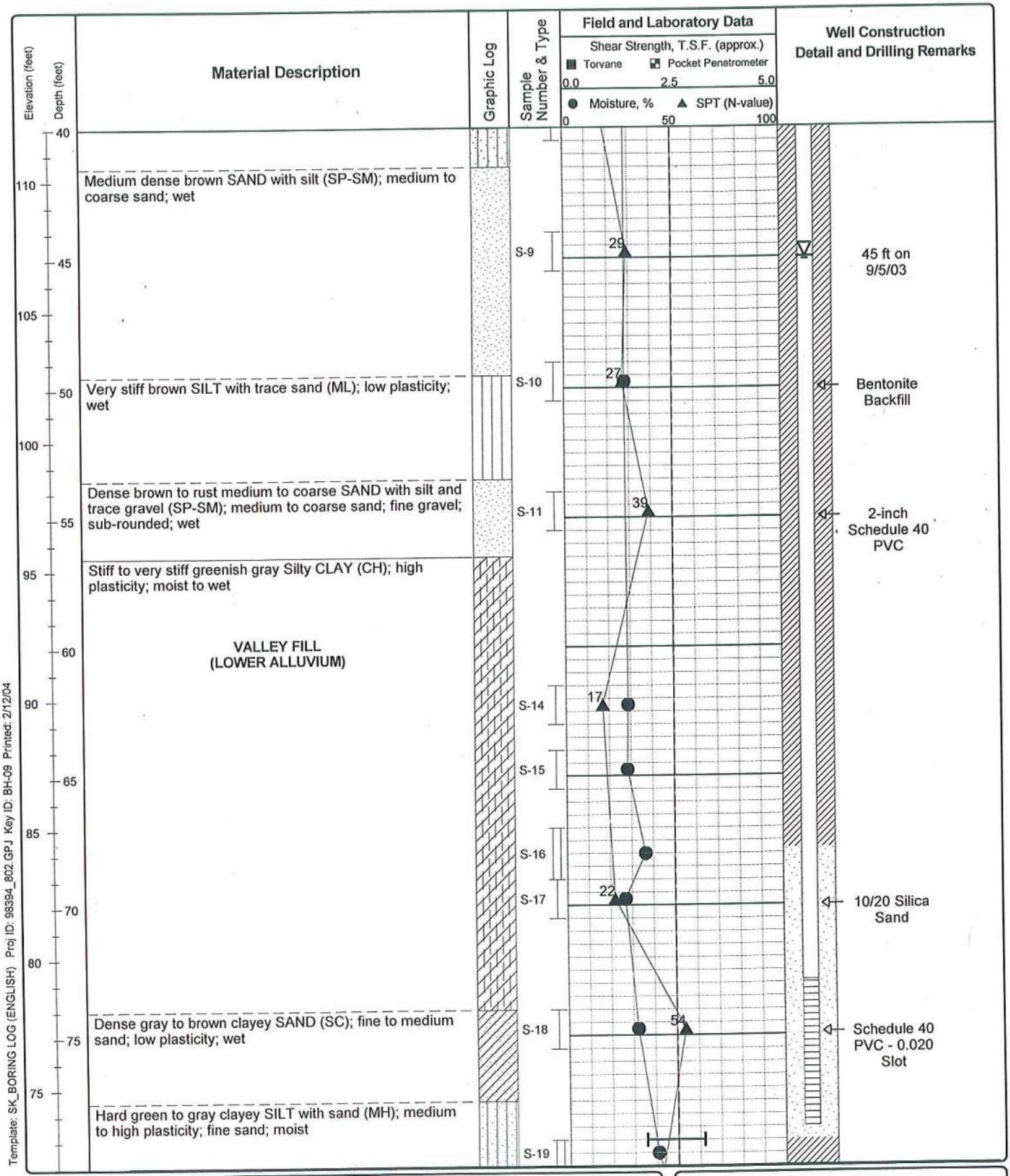
BORING LOG BH-09

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 3)

FIGURE A2



Date Drilling Started	8/25/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	111.5	Station:	Offset:
Surface Elevation (ft)	152.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639738.9 E 7620169.1

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

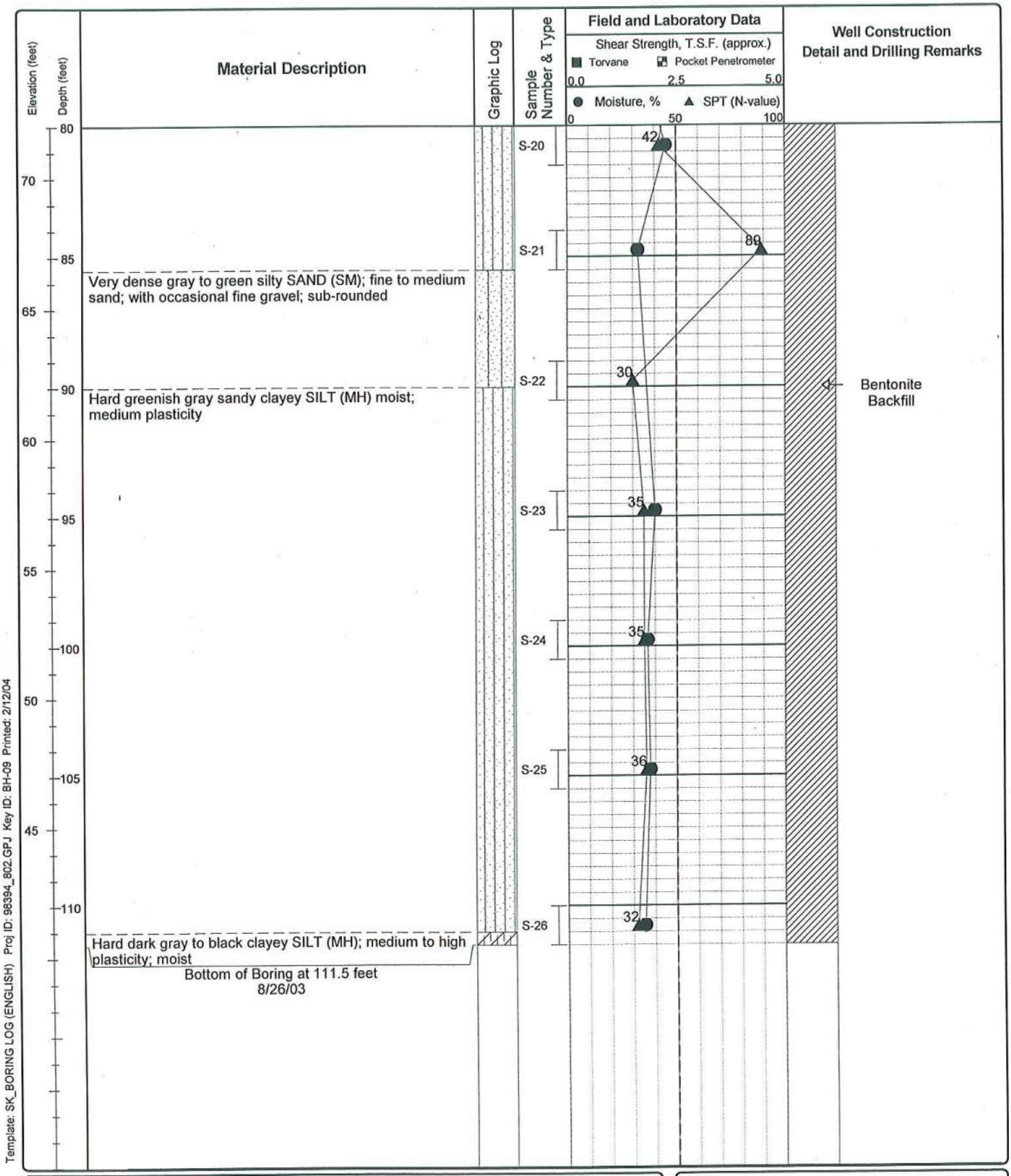
BORING LOG BH-09

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 2 of 3)

FIGURE A2



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-09 Printed: 2/12/04

Date Drilling Started: 8/25/03	Logged By: DRH	Location:	
Drilling Method: Casing Advance	Hammer Drop System:	Driller: Dave Abernathy	
Drill Rig Type: CME 75	Hammer Drop Length:	Wt. Drive Hammer:	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft):	Total Depth (ft): 111.5	Station:	Offset:
Surface Elevation (ft): 152.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639738.9	E 7620169.1

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

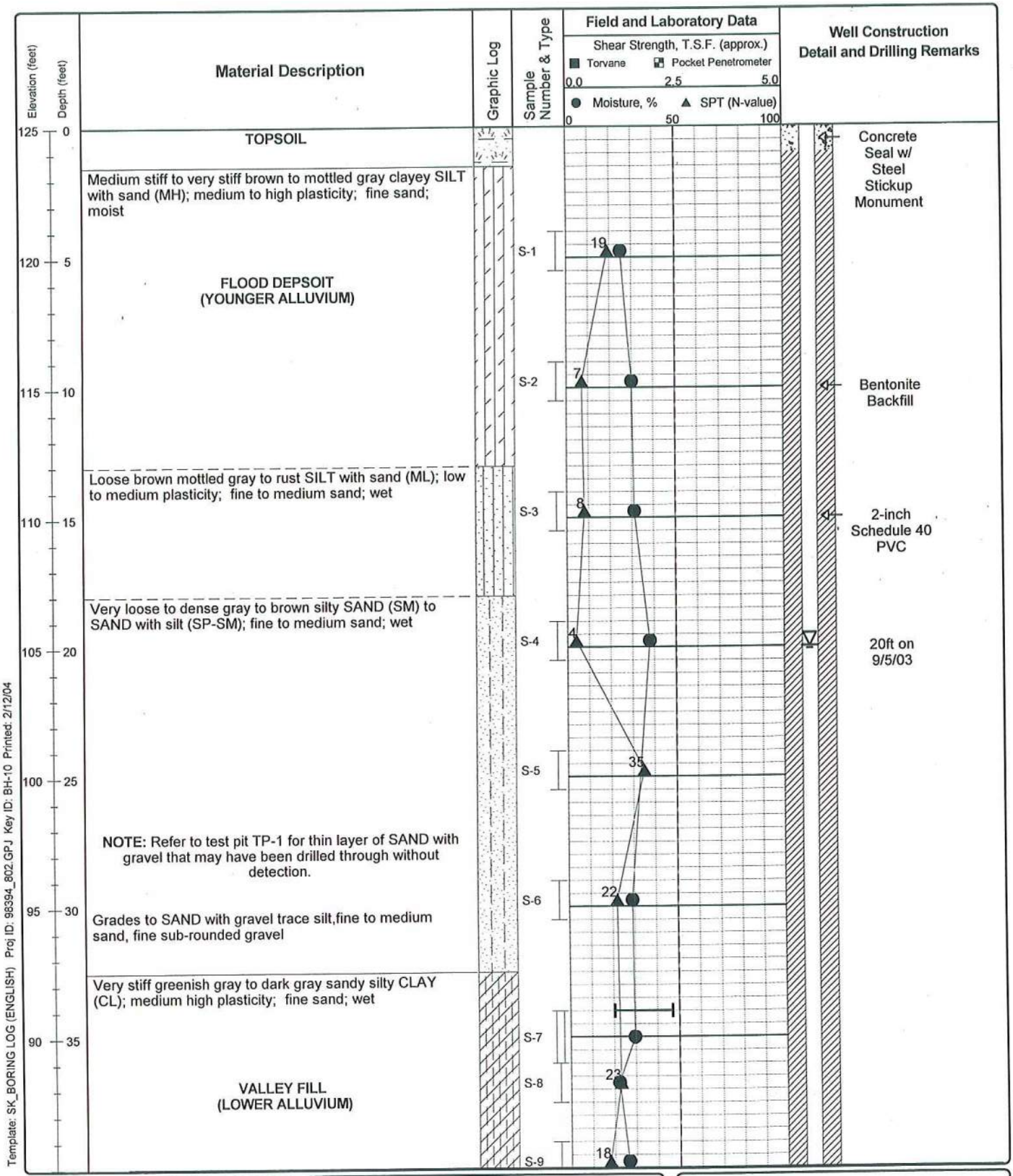
BORING LOG BH-09

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 3 of 3)

FIGURE A2



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-10 Printed: 2/12/04

Date Drilling Started	8/27/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	81.5	Station:	Offset:
Surface Elevation (ft)	125.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639500.1 E 7620076.9

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

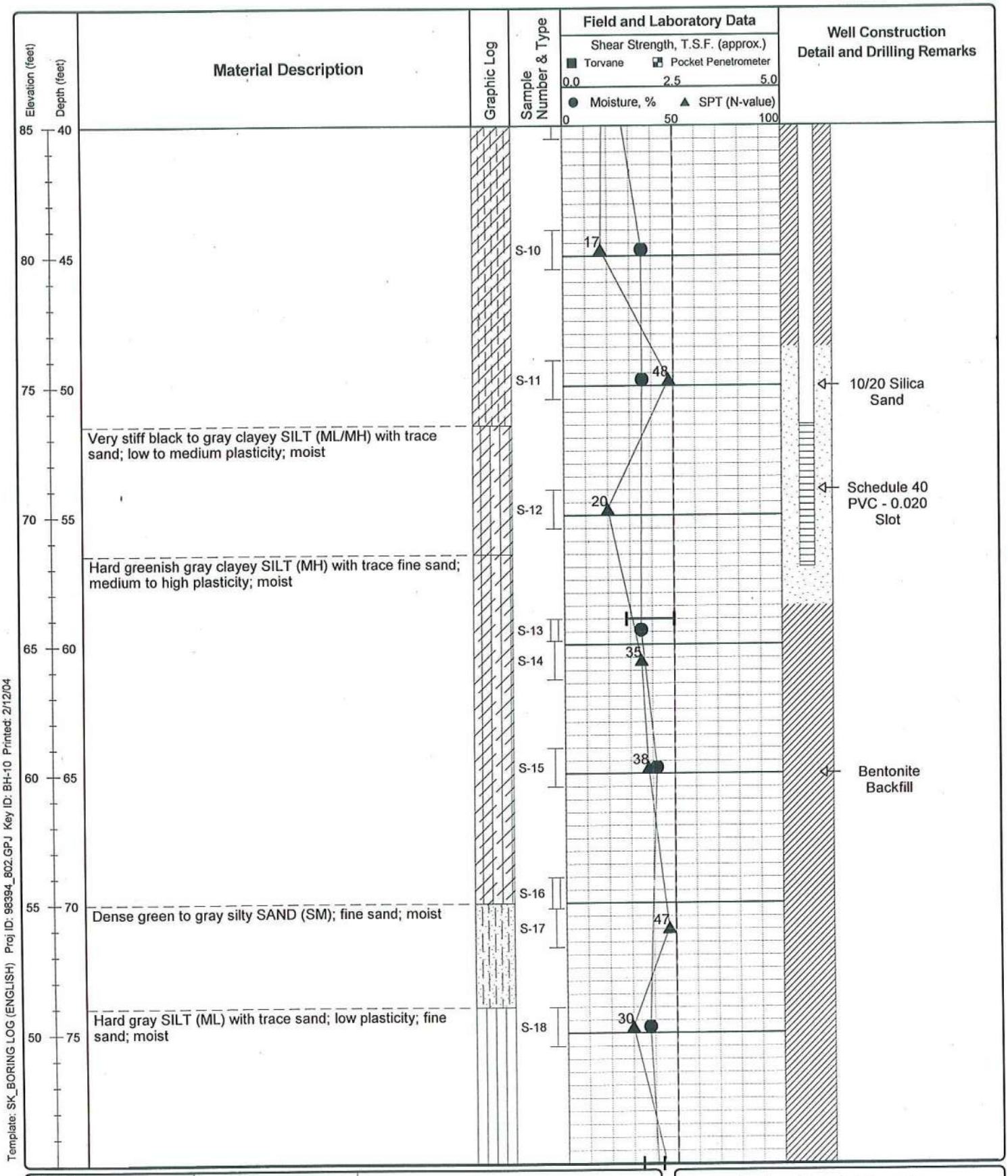
BORING LOG BH-10

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 3)

FIGURE A3



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-10 Printed: 2/12/04

Date Drilling Started	8/27/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	81.5	Station:	Offset:
Surface Elevation (ft)	125.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639500.1 E 7620076.9

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

BORING LOG BH-10

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SQUIER | KLEINFELDER

(Sheet 2 of 3)

FIGURE A3

Elevation (feet)	Depth (feet)	Material Description	Graphic Log	Sample Number & Type	Field and Laboratory Data	Well Construction Detail and Drilling Remarks
45	80			S-19	Shear Strength, T.S.F. (approx.) ■ Torvane ▦ Pocket Penetrometer 0.0 2.5 5.0; ● Moisture, % ▲ SPT (N-value) 0 50 100	
		Bottom of Boring at 81.5 feet 8/28/03				

Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-10 Printed: 2/12/04

Date Drilling Started: 8/27/03	Logged By: DRH	Location:	
Drilling Method: Casing Advance	Hammer Drop System:	Driller: Dave Abernathy	
Drill Rig Type: CME 75	Hammer Drop Length:	Wt. Drive Hammer:	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft):	Total Depth (ft): 81.5	Station:	Offset:
Surface Elevation (ft): 125.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639500.1	E 7620076.9

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

BORING LOG BH-10

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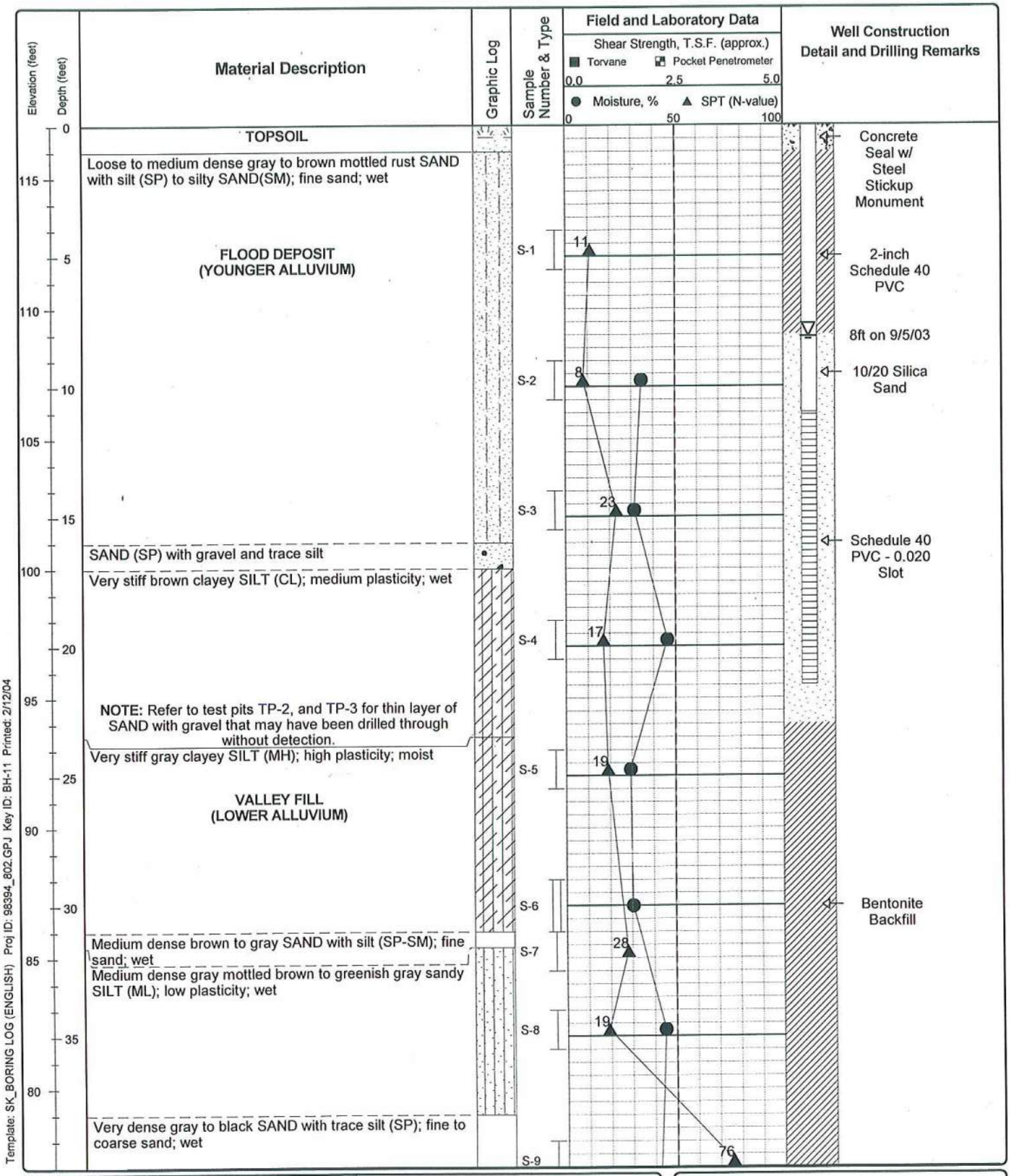
SQUIER | KLEINFELDER

(Sheet 3 of 3)

FIGURE A3



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-11 Printed: 2/12/04

Date Drilling Started	9/2/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	61.5	Station:	Offset:
Surface Elevation (ft)	117.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639382.5 E 7620350.0

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

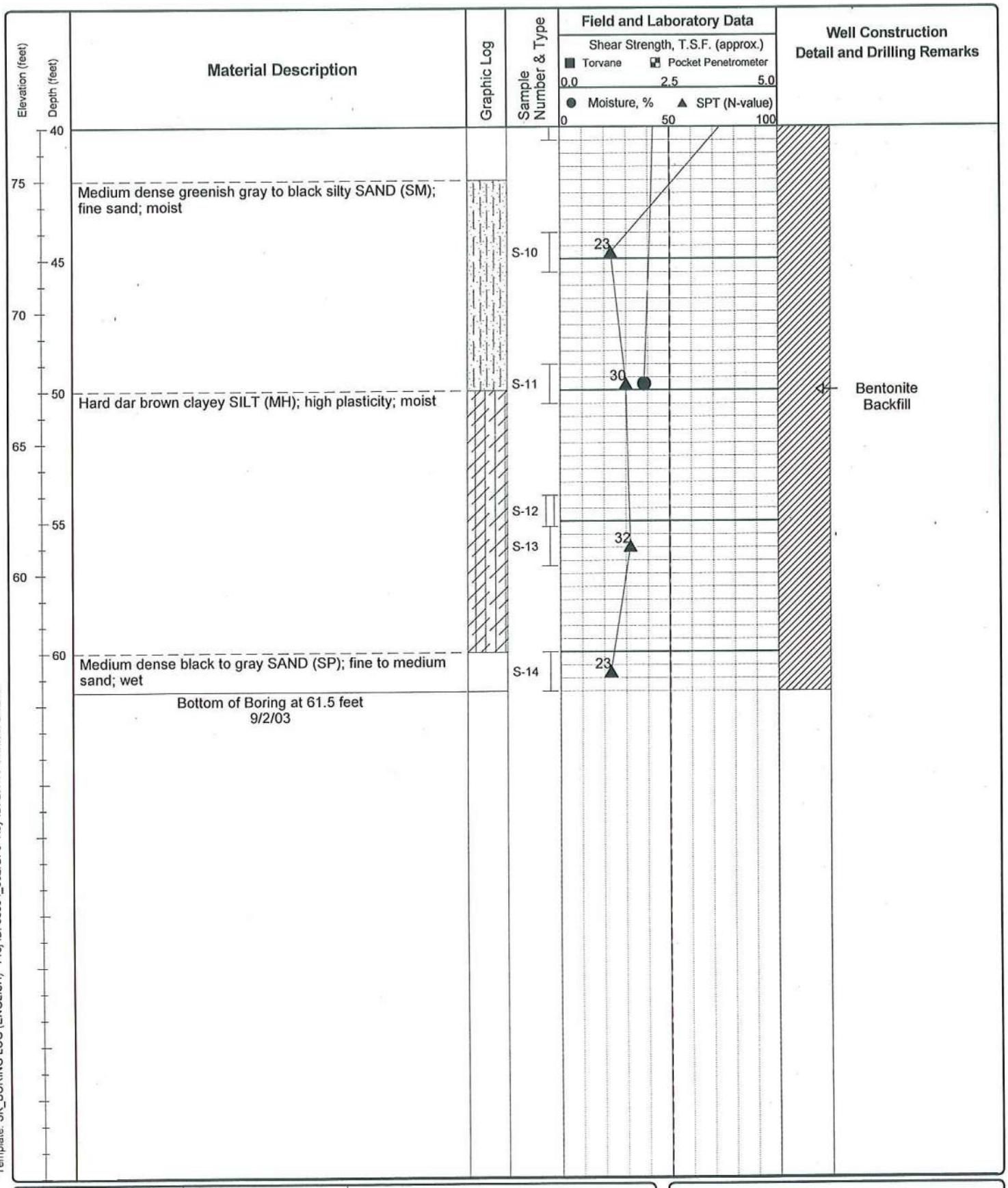
BORING LOG BH-11

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 2)

FIGURE A4



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-11 Printed: 2/12/04

Date Drilling Started: 9/2/03	Logged By: DRH	Location:	
Drilling Method: Casing Advance	Hammer Drop System:	Driller: Dave Abernathy	
Drill Rig Type: CME 75	Hammer Drop Length:	Wt. Drive Hammer:	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft):	Total Depth (ft): 61.5	Station:	Offset:
Surface Elevation (ft): 117.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639382.5	E 7620350.0

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

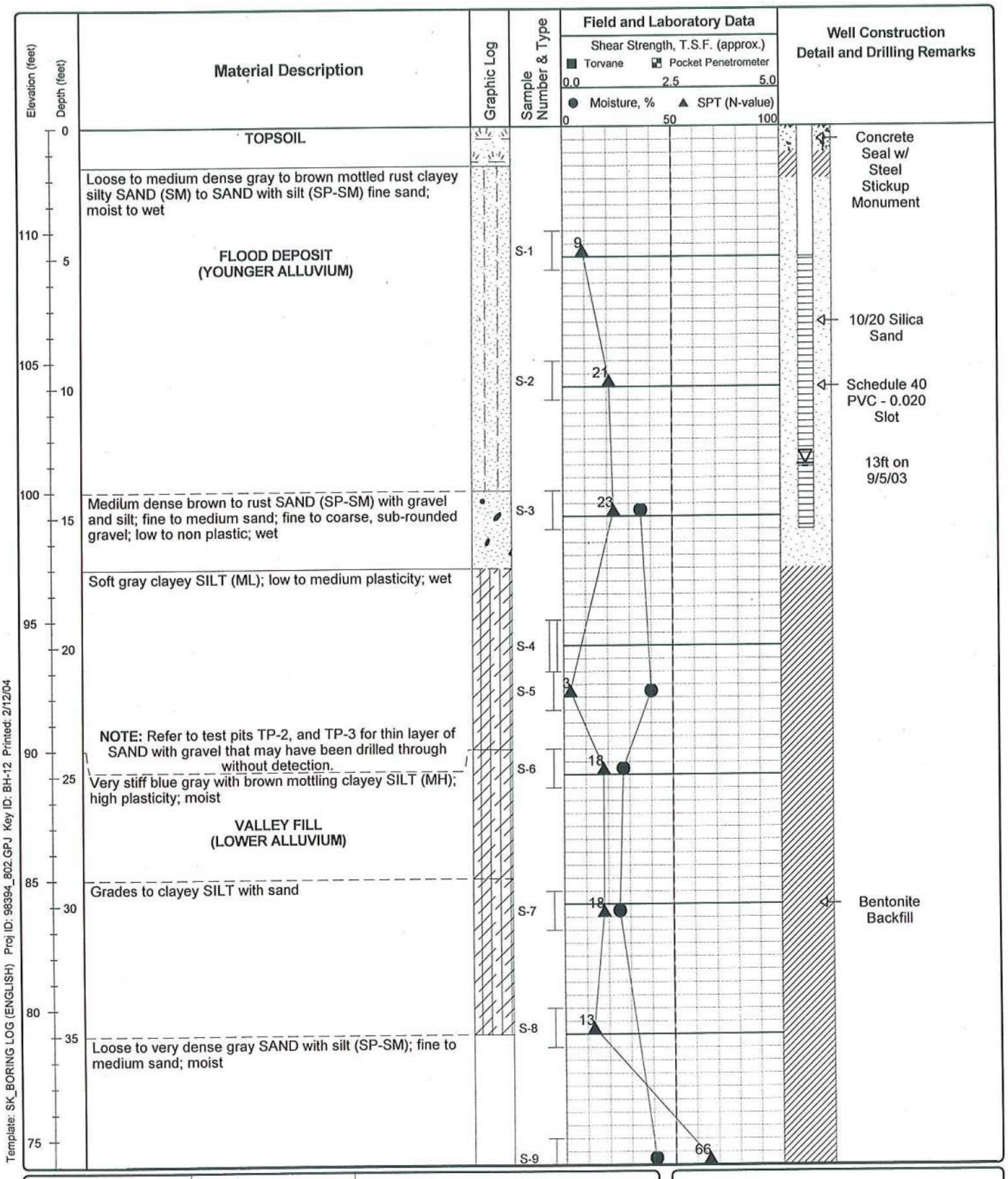
BORING LOG BH-11

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 2 of 2)

FIGURE A4



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-12 Printed: 2/12/04

Date Drilling Started	9/3/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	51.5	Station:	Offset:
Surface Elevation (ft)	114.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639314.2 E 7620435.4

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

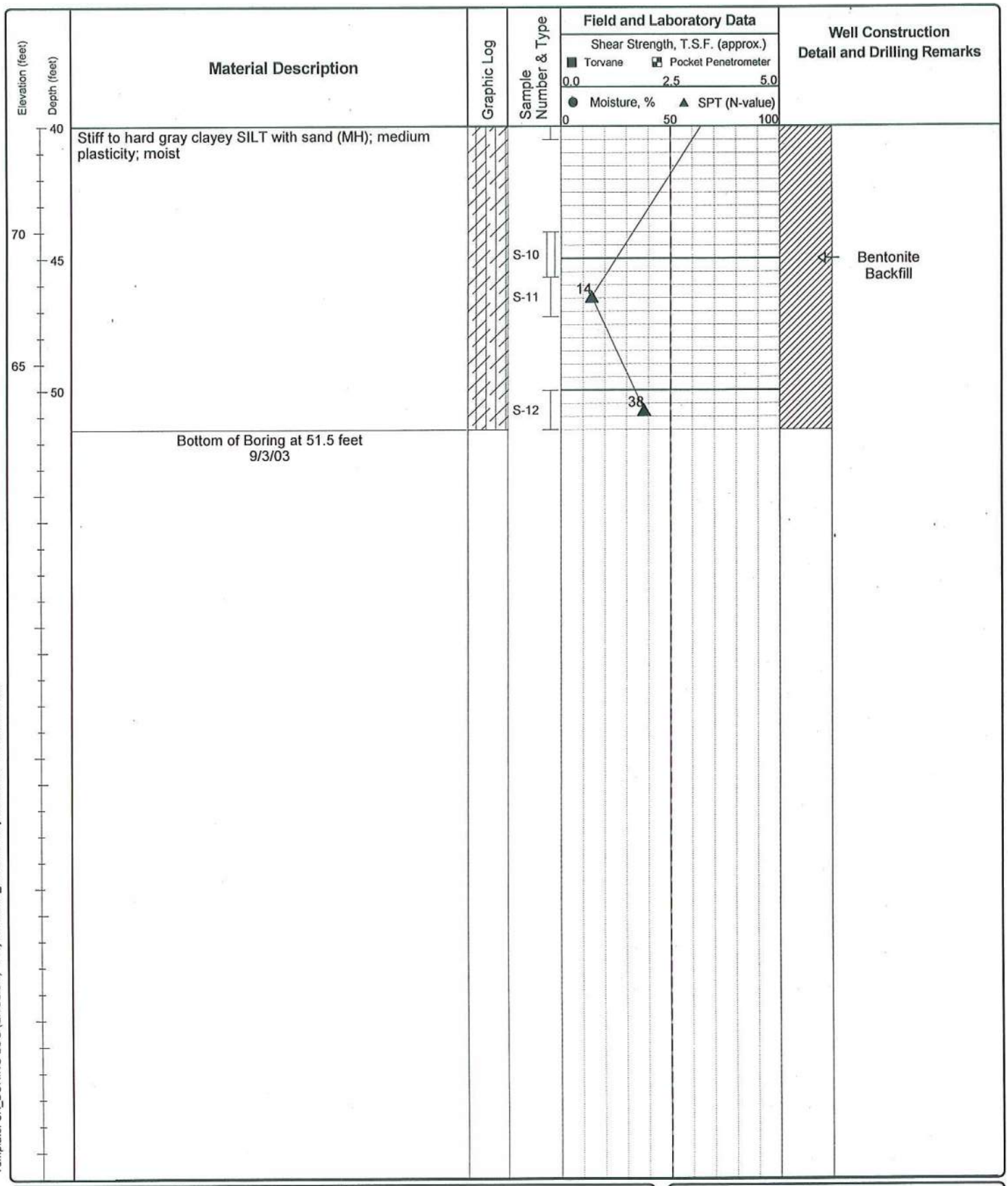
BORING LOG BH-12

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 2)

FIGURE A5



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-12 Printed: 2/12/04

Date Drilling Started: 9/3/03	Logged By: DRH	Location	
Drilling Method: Casing Advance	Hammer Drop System	Driller: Dave Abernathy	
Drill Rig Type: CME 75	Hammer Drop Length	Wt. Drive Hammer	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft)	Total Depth (ft): 51.5	Station:	Offset:
Surface Elevation (ft): 114.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639314.2	E 7620435.4

Durham Phase #4 Expansion

BORING LOG BH-12

Project No. 98394.802

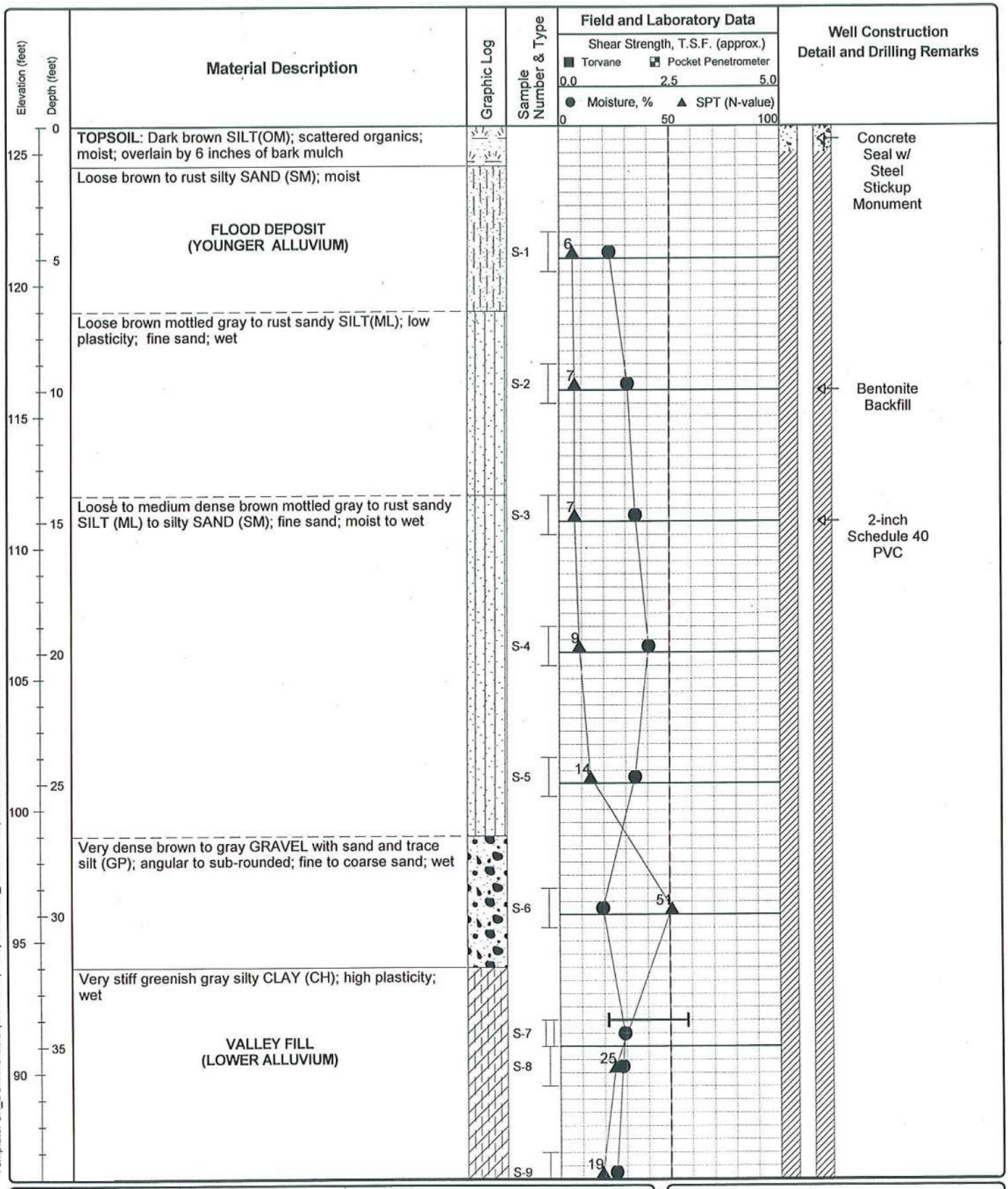
SQUIER | KLEINFELDER

(Sheet 2 of 2)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

FIGURE A5



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-13 Printed: 2/12/04

Date Drilling Started	8/28/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	81.5	Station:	Offset:
Surface Elevation (ft)	126.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639614.2 E 7619984.6

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

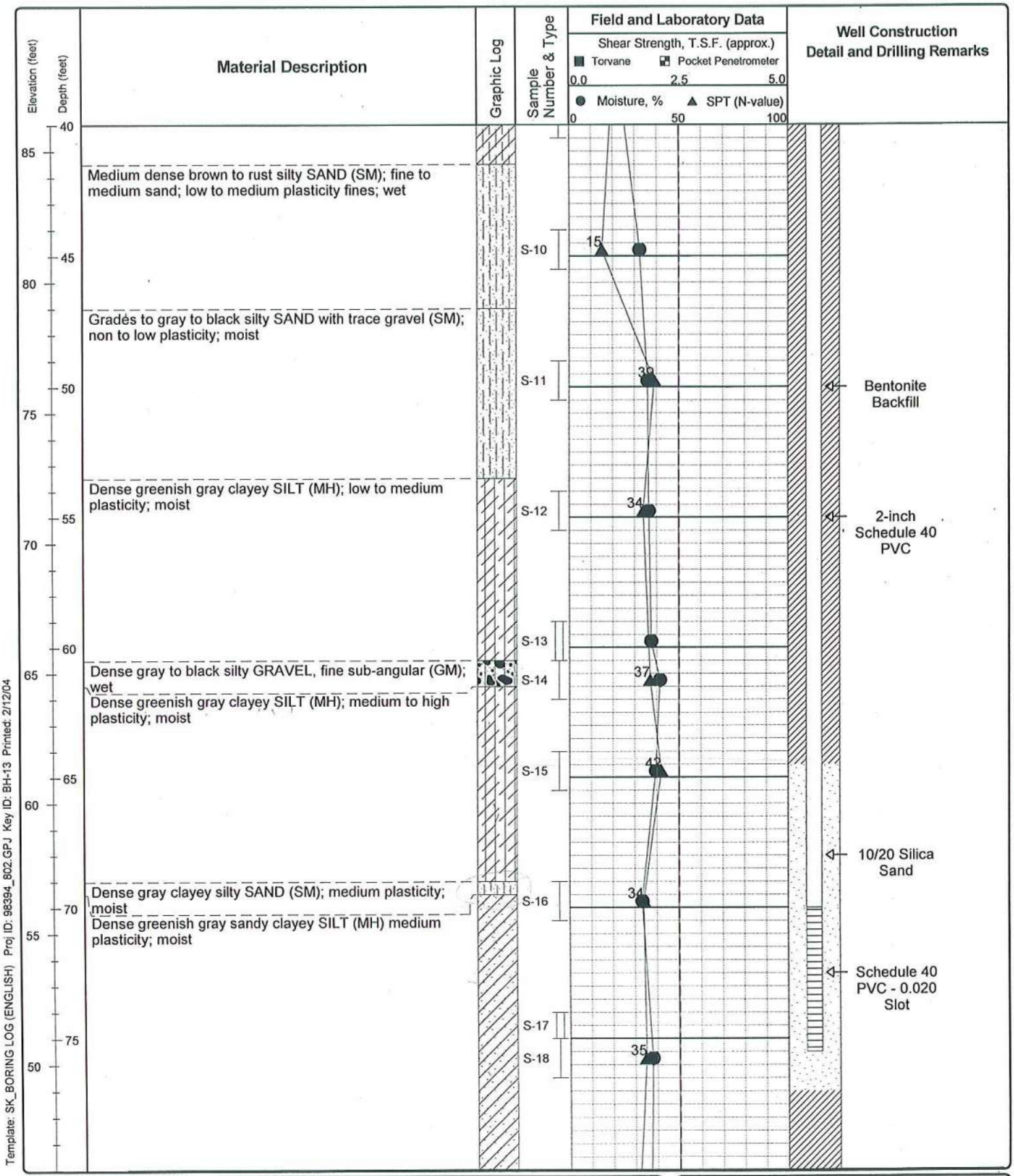
BORING LOG BH-13

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 3)

FIGURE A6



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-13 Printed: 2/12/04

Date Drilling Started	8/28/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	81.5	Station:	Offset:
Surface Elevation (ft)	126.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639614.2 E 7619984.6

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

BORING LOG BH-13

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 2 of 3)

FIGURE A6

Elevation (feet)	Depth (feet)	Material Description	Graphic Log	Sample Number & Type	Field and Laboratory Data	Well Construction Detail and Drilling Remarks
	80				Shear Strength, T.S.F. (approx.) ■ Torvane ■ Pocket Penetrometer 0.0 2.5 5.0 ● Moisture, % ▲ SPT (N-value) 0 50 100	
45				S-19	32	
		Bottom of Boring at 81.5 feet 8/29/03				

Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-13 Printed: 2/12/04

Date Drilling Started: 8/28/03	Logged By: DRH	Location	
Drilling Method: Casing Advance	Hammer Drop System	Driller: Dave Abernathy	
Drill Rig Type: CME 75	Hammer Drop Length	Wt. Drive Hammer	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft)	Total Depth (ft): 81.5	Station:	Offset:
Surface Elevation (ft): 126.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639614.2	E 7619984.6

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

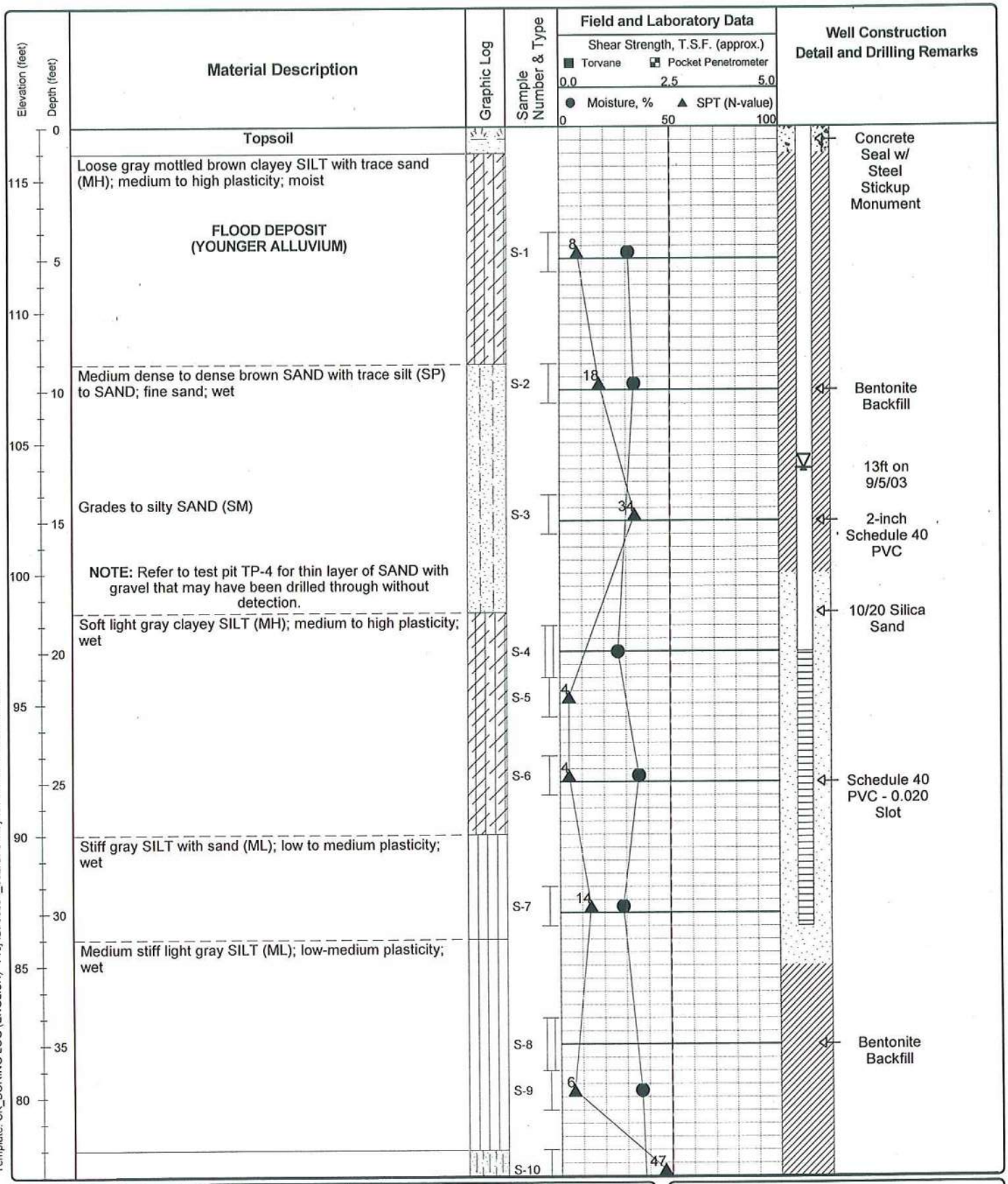
BORING LOG BH-13

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 3 of 3)

FIGURE A6



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-14 Printed: 2/12/04

Date Drilling Started	9/3/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	61.5	Station:	Offset:
Surface Elevation (ft)	117.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639204.0 E 7620174.9

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

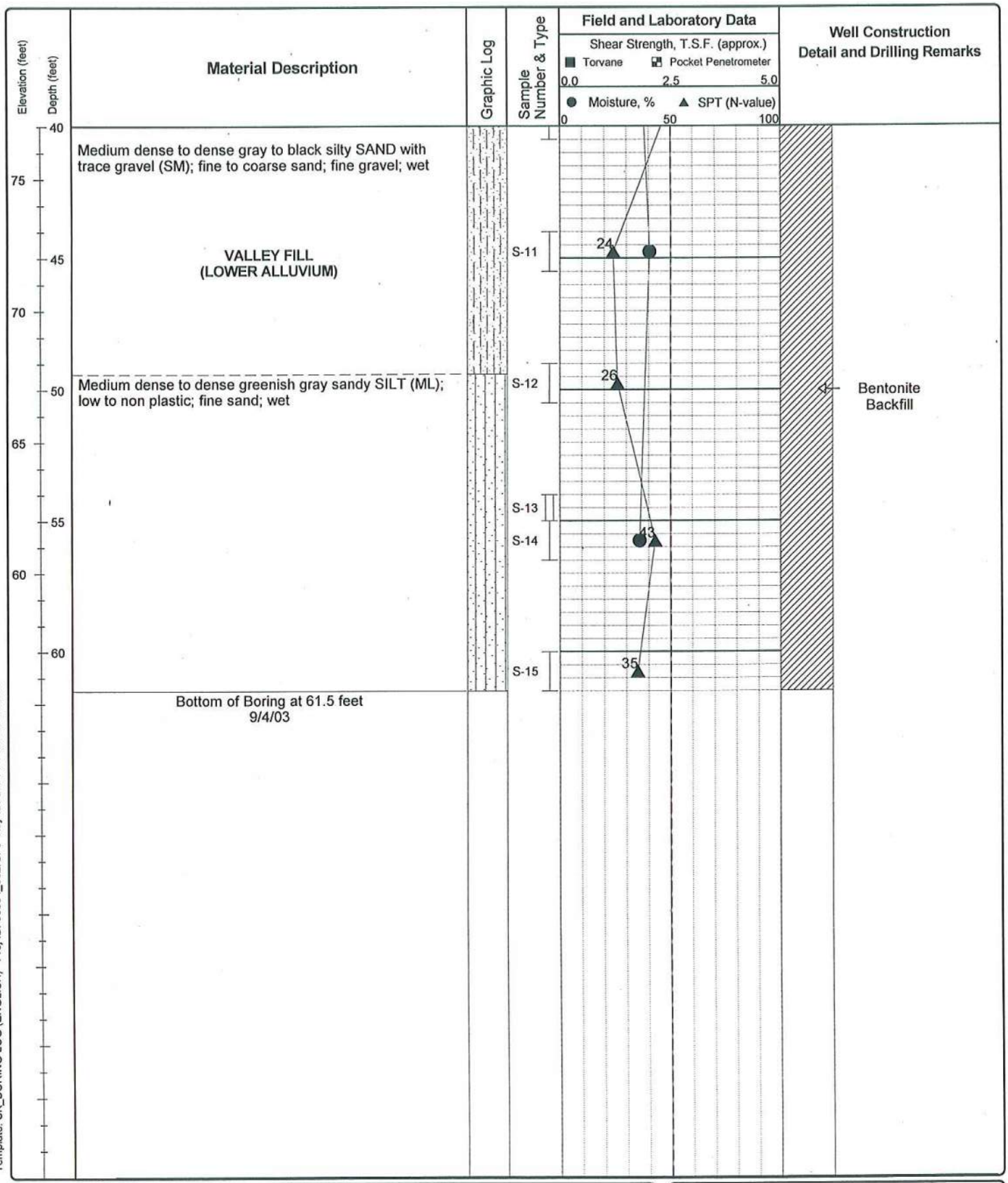
BORING LOG BH-14

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 2)

FIGURE A7



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-14 Printed: 2/12/04

Date Drilling Started	9/3/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Dave Abernathy
Drill Rig Type	CME 75	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	61.5	Station:	Offset:
Surface Elevation (ft)	117.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639204.0 E 7620174.9

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

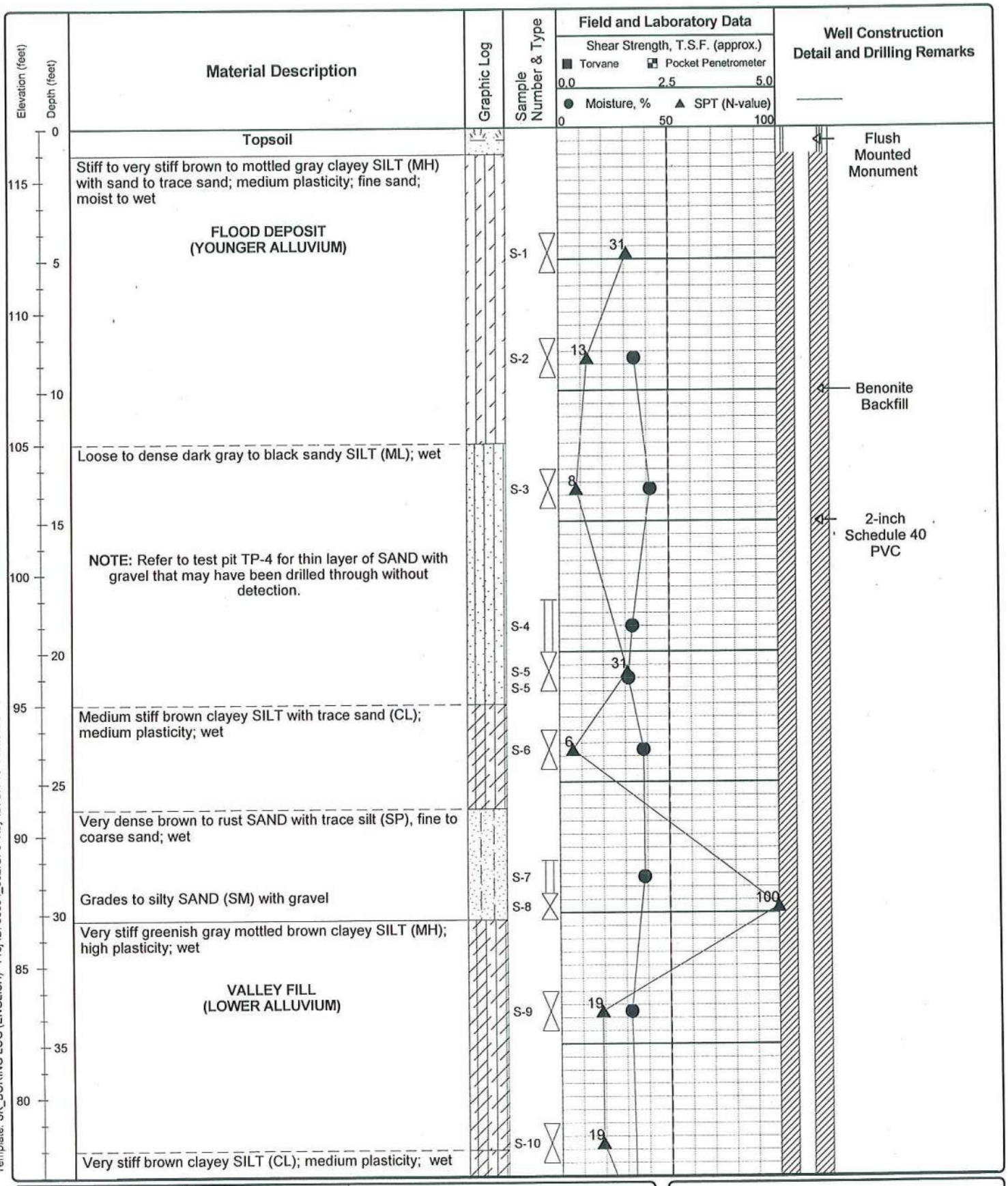
BORING LOG BH-14

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 2 of 2)

FIGURE A7



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-15 Printed: 2/12/04

Date Drilling Started	9/29/03	Logged By	DRH	Location	
Drilling Method	Casing Advance	Hammer Drop System		Driller	Joel Welsh
Drill Rig Type	Mobile B-59	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	54.5	Station:	Offset:
Surface Elevation (ft)	117.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 639325.1 E 7620138.6

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

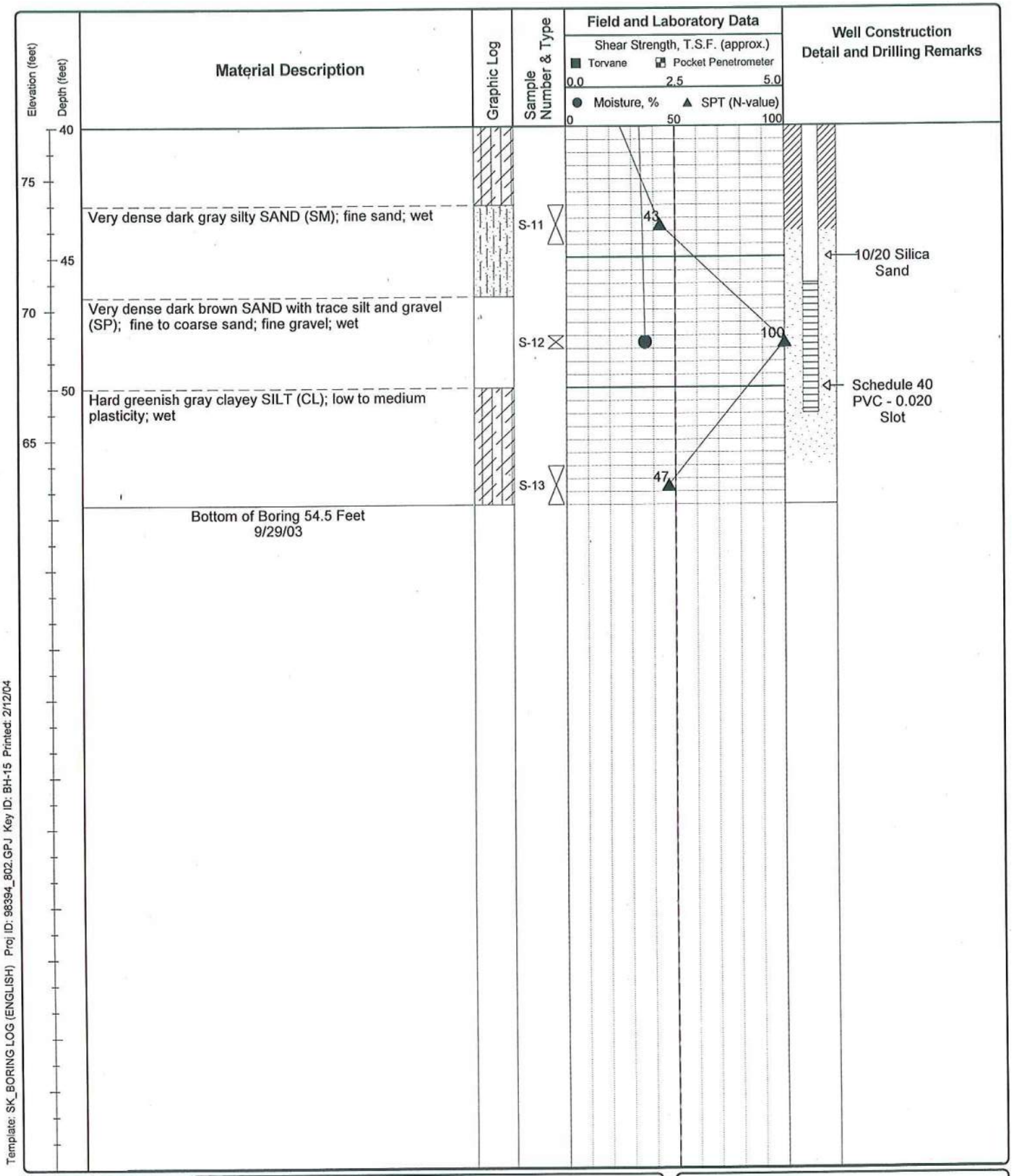
BORING LOG BH-15

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 1 of 2)

FIGURE A8



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-15 Printed: 2/12/04

Date Drilling Started: 9/29/03	Logged By: DRH	Location	
Drilling Method: Casing Advance	Hammer Drop System	Driller: Joel Welsh	
Drill Rig Type: Mobile B-59	Hammer Drop Length	Wt. Drive Hammer	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft)	Total Depth (ft): 54.5	Station:	Offset:
Surface Elevation (ft): 117.0	Elevation Datum (ft.): NAD 83	Coordinates: N 639325.1	E 7620138.6

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

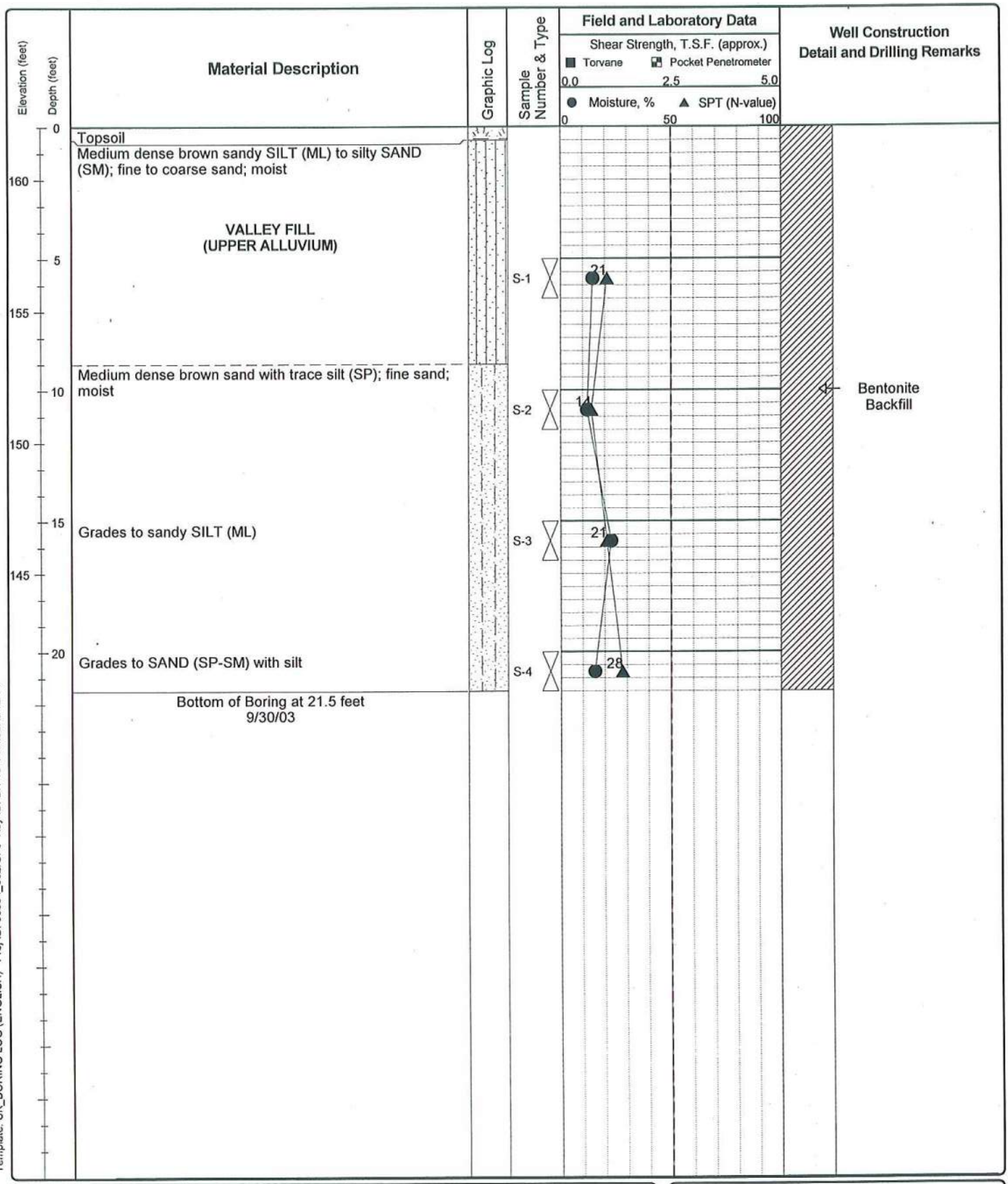
BORING LOG BH-15

Project No. 98394.802

SQUIER | KLEINFELDER

(Sheet 2 of 2)

FIGURE A8



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-16 Printed: 2/12/04

Date Drilling Started	9/30/03	Logged By	DRH	Location	
Drilling Method	Hollow Stem Auger	Hammer Drop System		Driller	Joel Welsh
Drill Rig Type	Mobile B-59	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	21.5	Station:	Offset:
Surface Elevation (ft)	162.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N E

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

BORING LOG BH-16

Project No. 98394.802

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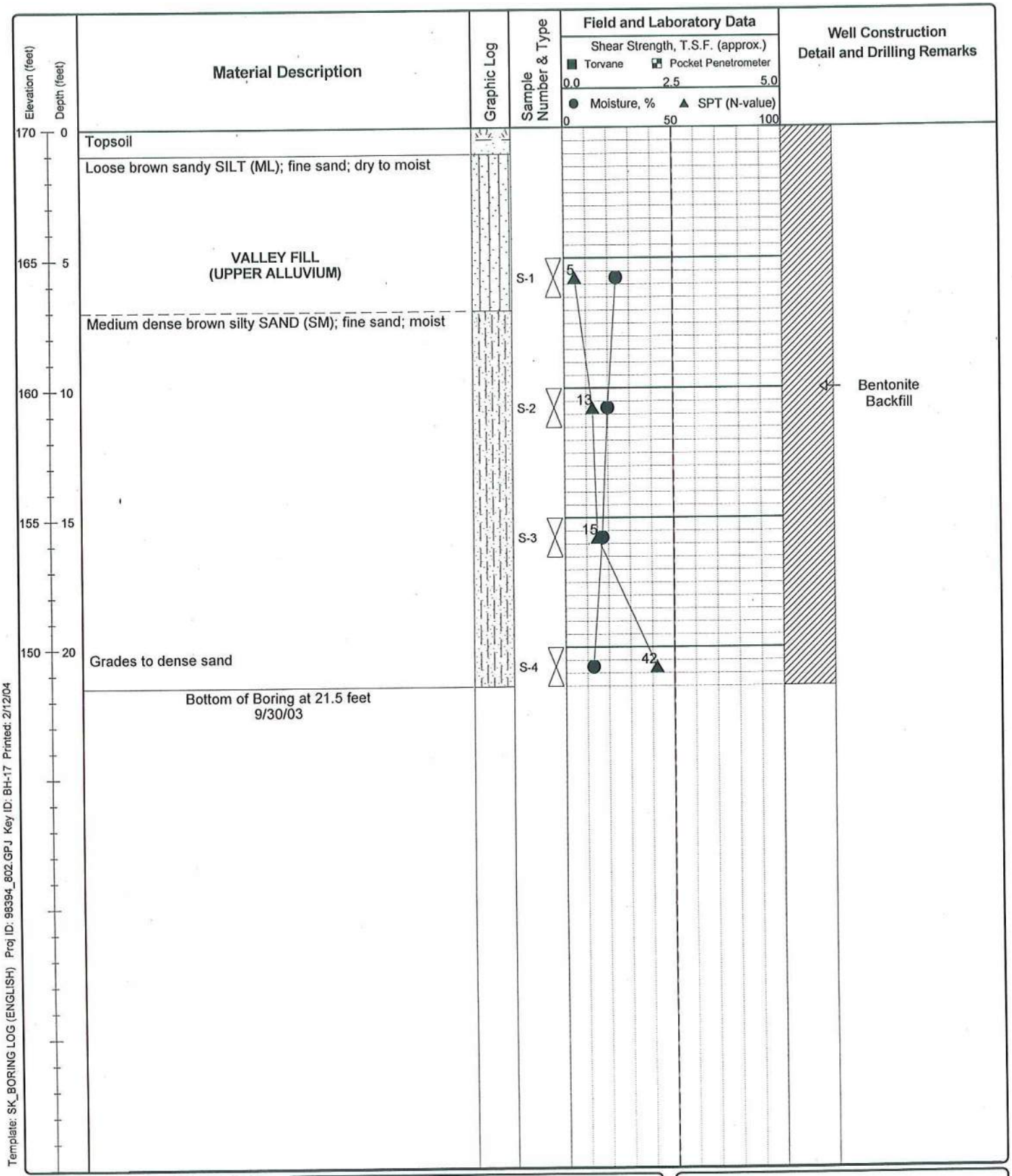
(Sheet 1 of 1)

FIGURE A9



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-17 Printed: 2/12/04

Date Drilling Started: 9/30/03	Logged By: DRH	Location:	
Drilling Method: Hollow Stem Auger	Hammer Drop System:	Driller: Joel Welsh	
Drill Rig Type: Mobile B-59	Hammer Drop Length:	Wt. Drive Hammer:	Borehole Diameter (in.): 4.5-inch
Casing Depth (ft):	Total Depth (ft): 21.5	Station:	Offset:
Surface Elevation (ft): 170.0	Elevation Datum (ft.): NAD 83	Coordinates: N	E

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

BORING LOG BH-17

Project No. 98394.802

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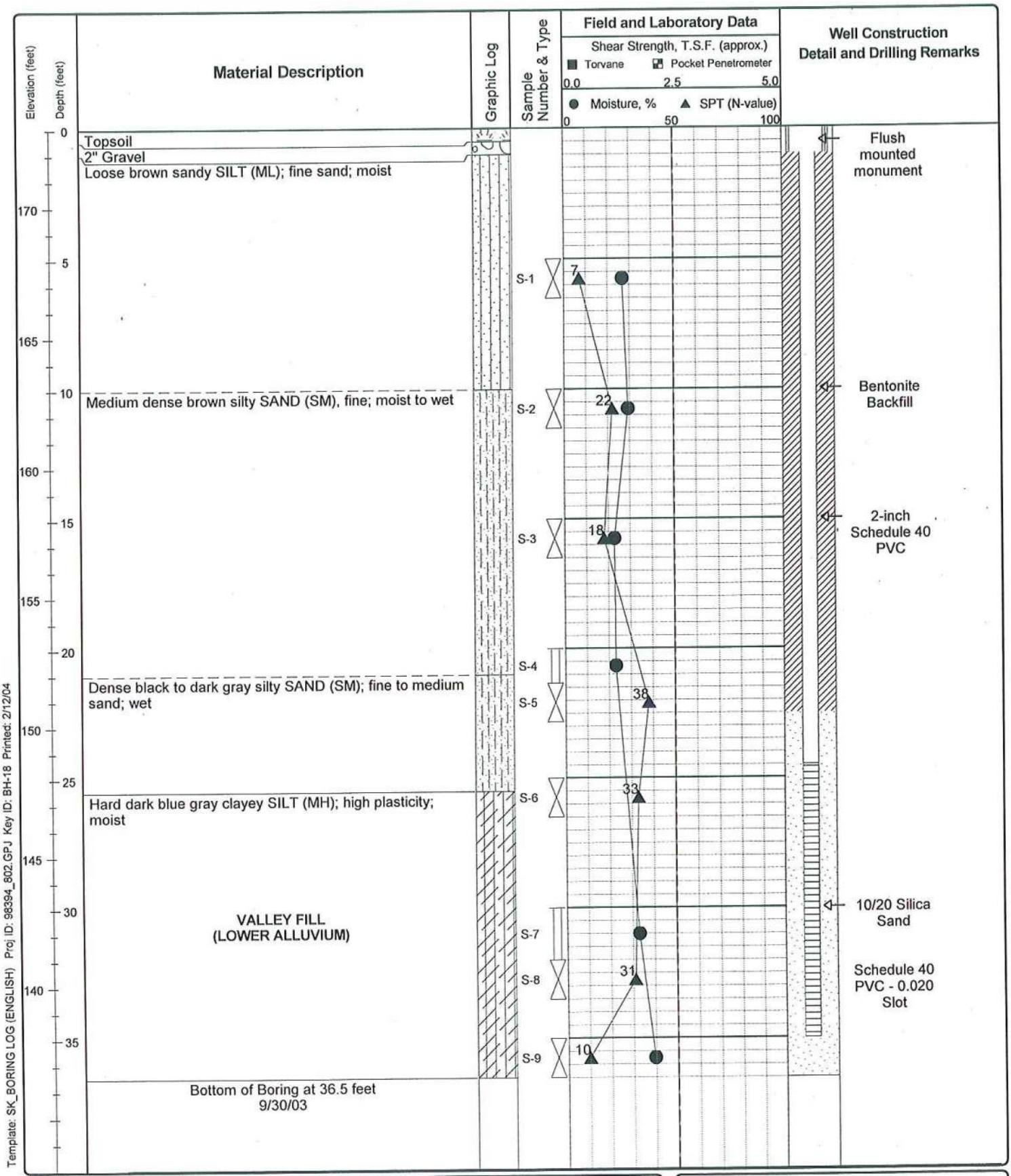
(Sheet 1 of 1)

FIGURE A10



Template: SK_BORING LOG (ENGLISH) Proj ID: 98394_802.GPJ Key ID: BH-18 Printed: 2/12/04

Date Drilling Started	9/30/03	Logged By	DRH	Location	
Drilling Method	Hollow Stem Auger	Hammer Drop System		Driller	Joel Welsh
Drill Rig Type	Mobile B-59	Hammer Drop Length		Wt. Drive Hammer	Borehole Diameter (in.) 4.5-inch
Casing Depth (ft)		Total Depth (ft)	36.5	Station:	Offset:
Surface Elevation (ft)	173.0	Elevation Datum (ft.)	NAD 83	Coordinates:	N 640692.1 E 7620473.5

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

BORING LOG BH-18

Project No. 98394.802

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(Sheet 1 of 1)

FIGURE A11

Back-fill	Remarks	Elev. (Depth) Feet 122.5	Approximate Ground Surface Elevation in Feet: 122.5 CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
		121.5	**TOPSOIL**		0	
		(1.0)	Medium stiff to very stiff brown to mottled gray clayey SILT with sand (MH); medium to high plasticity; fine sand; moist		2	
		118.5	**FLOOD DEPOSIT (YOUNGER ALLUVIUM)**		4	
		(4.0)	Gray to brown SILT (ML) with sand		6	S-1
					8	
					10	
		111.5				
		(11.0)	Gray with brown mottled SAND (SP-SM) with silt, fine sand; wet		12	
					14	
←	Caving Sands				16	
					18	
		103.5				
		(19.0)	Brown SILT (ML) with sand		20	
		102.0				
		(20.5)	Gray to brown SAND (SP-SM) with silt, fine to medium sand		22	
		100.0				
		(22.5)	Gray to brown SAND (SP) with gravel and occasional cobbles with trace silt, fine to coarse sand, fine to			S-2
		98.5			24	
		(24.0)	coarse gravel; wet			

Bottom of Test Pit at 24 ft
11/11/2003

NOTE: Terminated excavation due to caving and running in of trench sidewalls. A static water level was not obtained.

△ Dry Density, P.C.F.
● Natural Water Content, %
0 50 100

0.0 2.5 5.0
Shear Strength, T.S.F. (approx.)
■ Torvane
▪ Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Jar Sample
- □ = Bag Sample
- ▤ = CBR Test Sample
- ∿∿ = Seepage

▽ Ground Water Level as Measured on Date Shown (May Vary with Time of Year)

ATTERBERG LIMITS
- Liquid Limit
- Natural Water Content
- Plastic Limit

NOTE:
Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Durham Phase #4 Expansion

TEST PIT TP-1

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Templates: SK_TESTPIT NEWERTMP.GDT Proj. No. Printed: 2/12/04

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FIGURE A12

Back-fill	Remarks	Elev. (Depth) Feet	Approximate Ground Surface Elevation in Feet: 113.5 CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
		113.5				
			TOPSOIL		0	
		112.0 (1.5)	Loose to medium dense gray to brown mottled rust SAND with silt (SP) to silty SAND(SM); fine sand; wet **FLOOD DESPOSITS (YOUNGER ALLUVIUM)**		2 4 6 8 10 12 14	
~~▷		98.5 (15.0)	Dark gray to black SAND (SP) with gravel and trace silt, occasional cobbles, fine to medium sand; fine to coarse gravel; wet		16	S-1
		96.5 (17.0)	Soft gray silty CLAY (CL)		18	
		93.5 (20.0)	Light gray to black SAND (SP) with trace gravel, occasional cobbles and silt; fine to medium sand; wet		20	
		91.5 (22.0)	Greenish gray clayey SILT (MH) **VALLEY FILL (LOWER ALLUVIUM)**		22 24	
		87.5 (26.0)	**Bottom of Test Pit at 26 ft** **11/11/03** **NOTE:** Test pit did not remain open long enough to obtain a static water level.		26	

△ Dry Density, P.C.F.

● Natural Water Content, %

0 50 100

0.0 2.5 5.0

Shear Strength, T.S.F. (approx.)

■ Torvane

▪ Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Jar Sample
- □ = Bag Sample
- ≡ = CBR Test Sample
- ~~▷ = Seepage

▽ Ground Water Level as Measured on Date Shown (May Vary with Time of Year)

ATTERBERG LIMITS
- Liquid Limit
- Natural Water Content
- Plastic Limit

NOTE:
Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Durham Phase #4 Expansion

TEST PIT TP-2

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Templates: SK_TESTPIT NEWERTMP.GDT Proj. No. Printed: 2/12/04

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FIGURE A13

Back-fill	Remarks	Elev. (Depth) Feet 113.8	Approximate Ground Surface Elevation in Feet: 113.8 CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples	△ Dry Density, P.C.F. ● Natural Water Content, % 0 50 100
			TOPSOIL		0		
		112.3 (1.5)	Loose to medium dense gray to brown mottled rust clayey silty SAND (SM) to SAND with silt, fine sand; moist to wet **FLOOD DEPOSITS (YOUNGER ALLUVIUM)**		2 4 6 8 10 12 14		
~~▷		99.3 (14.5)	Brown SAND (SP-SM) with gravel and silt, occasional cobbles; fine to coarse sand; fine to coarse gravel; wet		16	S-1	●
		96.8 (17.0)	Gray clayey SILT (MH)		18		
		93.8 (20.0)	Light gray silty SAND (SM) to sandy SILT (ML)		20 22		
		90.8 (23.0) 89.3 (24.5)	Brown SAND (SP) with gravel and trace silt to gravelly SAND with trace silt, occasional cobbles; fine to coarse sand; fine to coarse gravel; wet Greenish gray SILT (ML) with sand, fine sand **VALLEY FILL (LOWER ALLUVIUM)**		24		
		87.8 (26.0)	**Bottom of Boring at 26 ft** **11/11/03**		26		

NOTE: Test pit did not remain open long enough to obtain a static water level.

0.0 2.5 5.0

Shear Strength, T.S.F. (approx.)

■ Torvane

▪ Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ☒ = Jar Sample
- □ = Bag Sample
- ☰ = CBR Test Sample
- ~~▷ = Seepage

NOTE:
Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

▽ Ground Water Level as Measured on Date Shown (May Vary with Time of Year)

ATTERBERG LIMITS
- Liquid Limit
- Natural Water Content
- Plastic Limit

Durham Phase #4 Expansion

TEST PIT TP-3

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Templates: SK_TESTPIT NEWERTMP.GDT Proj. No. Printed: 2/12/04

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FIGURE A14

Back-fill	Remarks	Elev. (Depth) Feet 115.1	Approximate Ground Surface Elevation in Feet: 115.1 CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples	△ Dry Density, P.C.F. ● Natural Water Content, % 0 50 100
		114.1	**TOPSOIL**		0		
		(1.0)	Brown clayey SILT (MH) with sand, fine sand; moist		2		
			FLOOD DEPOSIT (YOUNGER ALLUVIUIM)		4		
					6		
					8		
		105.1			10		
		(10.0)	Gray to brown to black silty SAND (SM) fine sand; moist to wet		12	S-1	
					14		
~~▷		99.1			16		
		(16.0)	Light gray SAND (SP) with gravel and trace silt, occasional cobbles; fine sand; fine to coarse gravel; wet				
		98.1			18		
		(17.0)	Gray silty CLAY (CL)				
					20		
		93.1			22		
		(22.0)	**Bottom of Boring at 22 ft 11/11/03**				

NOTE: Test pit did not remain open long enough to obtain a static water level.

0.0 2.5 5.0
Shear Strength, T.S.F. (approx.)
■ Torvane
Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Jar Sample
- □ = Bag Sample
- ≡ = CBR Test Sample
- ~~▷ = Seepage

▽ Ground Water Level as Measured on Date Shown (May Vary with Time of Year)

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE:
Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Durham Phase #4 Expansion

TEST PIT TP-4

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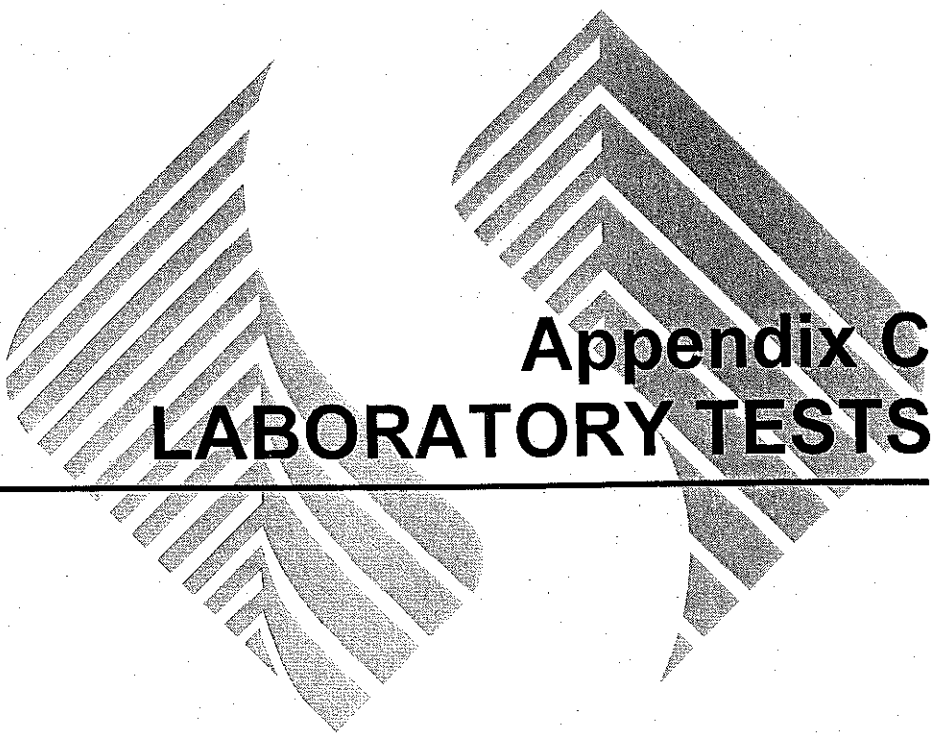
FIGURE A15

Templates: SK_TESTPIT NEWERTMP.GDT Proj. No. Printed: 2/12/04



Appendix C
LABORATORY TESTS

APPENDIX C
LABORATORY TESTS

General

The soil samples that were obtained during the field explorations were examined in our laboratory. The physical characteristics of the samples were noted and the field classifications were modified where necessary. During the course of the examination, representative samples were selected for further testing. The laboratory-testing program adopted for this investigation included a variety of tests to provide data for the various engineering analyses. The testing program included standard classification tests consisting of visual-manual examination, moisture contents, particle-size analyses, Atterberg limits, and unit weight measurements. In addition to the classification tests, unconfined compression tests and corrosivity tests were conducted to evaluate soil strength parameters and the potential corrosivity of the native soil. The testing procedures and results of the tests are presented in the following paragraphs. Unless noted otherwise, all test procedures followed local engineering practice.

Classification Tests

Visual-Manual Classification. The soils were classified in general accordance with the Unified Soil Classification System (ASTM D2488) with certain other terminology, such as the relative density or consistency of the soil deposits, also in general accordance with current local engineering practice. In determining the soil type (that is, gravel, sand, silt or clay) the term, which best described the major portion of the sample was used. Modifying terminology to further describe the samples is defined in Table A1.

Moisture (Water) Content. Natural moisture content determinations were made on samples of fine-grained soils (that is, silt, clay, and silty sand). The natural moisture content is defined as the ratio of the weight of water to dry weight of soil, expressed as a percentage. The results of the moisture content determinations are presented on the logs of the borings in Appendix A.

Atterberg Limits. Atterberg limits were determined on selected samples for the purpose of classifying fine-grained soils into various groups for correlation. The results of the Atterberg limits tests, which included liquid and plastic limits, are plotted on the Plasticity Chart, Figure C1 and C2, and on the log of the borings in Appendix A.

Particle Size Analyses. Particle size analyses were conducted on selected soil samples to determine their grain-size distribution. For each test, a wet sieve analyses was performed on the soil samples to

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determine a percentage (by weight) of the sample passing the No. 200 (0.75 mm) sieve, and the material retained on the No. 200 sieve was sieved through a series of sieves to determine the distribution of the plus No. 200. The results of the particle-size analyses are presented in the form of grain-size distribution curves on Figures C3 through C7.

Unit Weight of Undisturbed Samples

The unit weights, or densities, of undisturbed Shelby tube samples were determined in the laboratory. To determine the soil's wet unit weight, the dimensions of selected cylindrical samples were measured, the samples weighed, and the wet unit weights calculated. After oven drying, the moisture contents of the samples were determined and the dry unit weight computed.

Table C1
Unit Weight Test Results

Sample	Depth (ft)	Moisture Content %	Wet Density (pcf)	Dry Density (pcf)	Classification
BH-9, S-19	79	37.1	115.0	83.9	Gray SILT with sand
BH-10, S-7	34	29.6	123.5	95.3	Dark gray sandy silty CLAY
BH-10, S-13	59	34.9	118.9	88.1	Greenish gray clayey SILT
BH-11, S-6	29	30.4	124.1	95.2	Gray clayey SILT
BH-12, S-4	21	40.0	111.5	79.7	Gray SILT
BH-13, S-7	34	29.3	121.8	94.2	Greenish gray silty CLAY
BH-14, S-4	19	26.3	119.9	95.0	Light gray clayey SILT
BH-15, S-4	18	33.3	117.6	88.2	Gray Sandy SILT

Unconfined Compressive Strength of Cohesive Soil

Unconfined compression tests were performed in order to evaluate the undrained shear strength of selected Shelby tube soil samples. For each test, a cylindrical test specimen was axially loaded to failure in a test frame, at approximately 1 percent strain per minute. The unconfined compressive strength is the maximum value of load per unit area, or the load per unit area at 15 percent strain, whichever is reached first. The results of the unconfined compression tests are expressed in terms of shear strength, i.e.,

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unconfined compressive strength divided by 2. The results of the unconfined compression tests are presented as axial stress versus axial stain plots in Figures C8 through C15.

Compaction Test

A Modified Proctor compaction test (1557-78, Method A), was performed on the sample TP-1/S-1 to obtain moisture-density relationship for evaluation of soil as backfill material. The test results are expressed as a curve of compacted dry density versus molding moisture content on Figure C16. As shown on Figure C16, the maximum dry density was about 112 pcf, with optimum moisture content about 15.5 percent.

Soil Corrosivity Tests

To evaluate the potential corrosivity of the native soils, selected samples, collected from selected depths, were tested for the chemical concentrations of corrosive anions (sulfide, sulfate, and chloride) as well as the characterization values of pH and soil resistivity. The analytical results of the tests are summarized in the Table C2.

Table C2
Corrosivity Test Results

Sample	Depth (ft)	Chloride mg/kg	Sulfate mg/kg	PH	Resistivity (ohm-cm)
BH-9, S-5	24	ND	ND	6.0	17,000
BH-17, S-1	5	ND	ND	5.3	11,000
BH-18, S-1	5	ND	109	5.4	5,500
BH-18, S-6	25	ND	ND	7.2	2,100

Resistivity is the numerical expression of the ability of a soil to impede the transmission of an electrical current. Resistivity is the inverse of conductivity and dependent on the presence of ions, concentrations, mobility, valence, soil moisture, and temperature.

The corrosion potential is primarily evaluated using the measured resistivity values. Measured resistivity values were obtained using Washington State Department of Transportation (WSDOT) Method Number 417. The following typical corrosivity potential is based on Petroleum Equipment Institute, No. RP-100-90 (1990):

Corrosive Soil: 2,000 ohm-cm or less

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Mildly Corrosive Soil:	5,000 ohm-cm
Slightly Corrosive Soil:	15,000 ohm-cm

Soil pH is a measurement of the hydrogen ion activity of the soil. Soil pH is reported in Standard Units (S.U.) on a scale ranging from 0 S.U. to 14 S.U., with 7 S.U. being neutral. Soils with a pH greater than 7 S.U. are considered alkaline and soils with a pH less than 7 S.U. are considered acidic. According to current industry guidelines and regulations, alkaline solids with a pH greater than or equal to 12.5 S.U. and acidic soils with a pH less than 2.5 S.U. are considered corrosive.

Sulfates and chlorides were also measured in the selected soil samples. Sulfates can be converted to sulfides by naturally occurring bacteria. Sulfides, when allowed to oxidize, will produce sulfuric acid, which is highly corrosive. Chlorides will also chemically react and facilitate dissolution reactions with metals and concrete. Chorides were not detected in all four selected soil samples.

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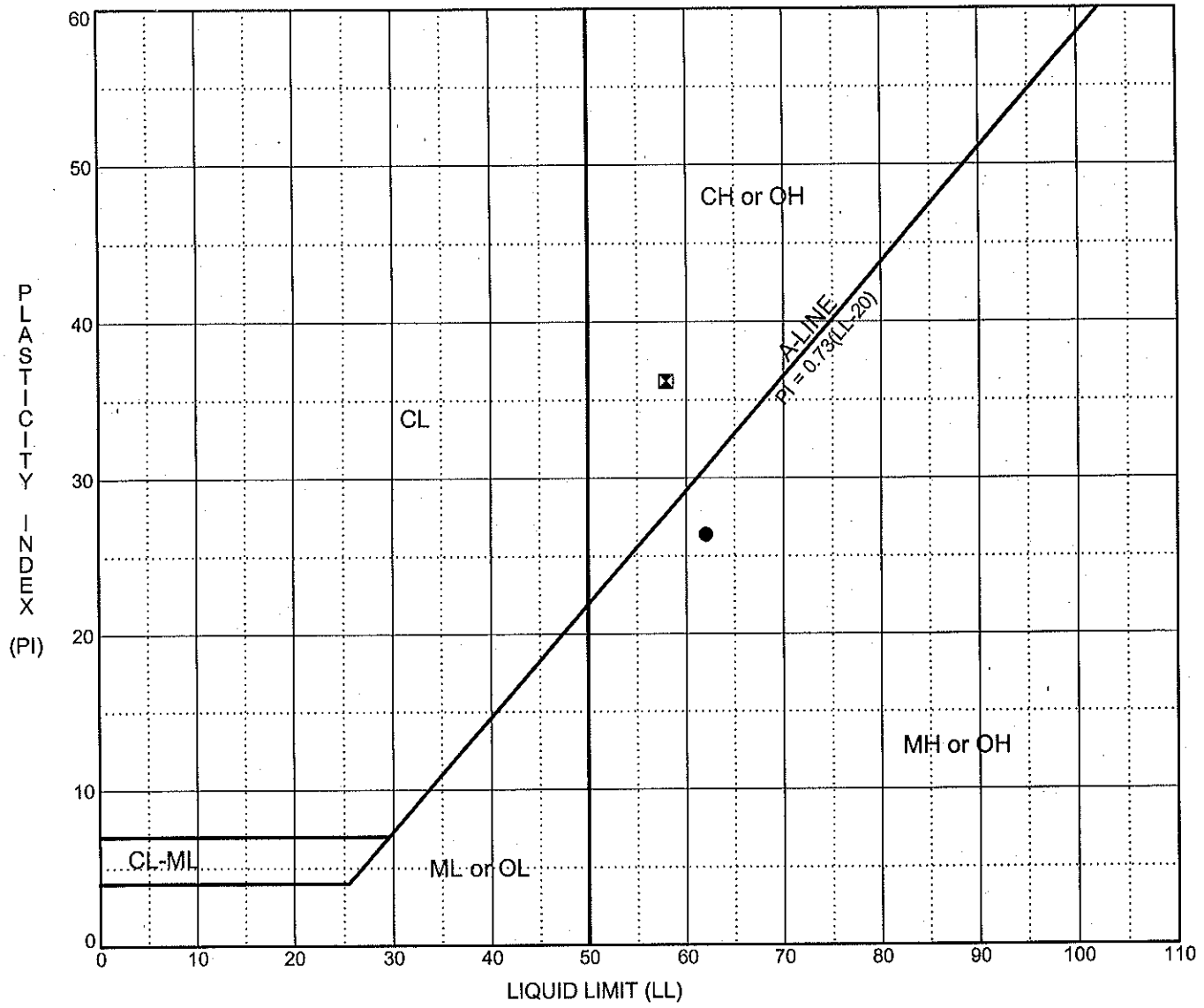

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	LL	PL	PI	WC %	VISUAL-MANUAL CLASSIFICATION
● BH-09	S-19	79.0	MH	62	36	26	41.0	Grey clayey SILT
⊠ BH-13	S-7	34.0	CH	58	22	36	29.3	Dark grey CLAY

NOTE: Atterberg Limits were performed on minus NO.40 sieve size material

GROUP Unified Soil Classification System (USCS) Fine-Grained Soil Groups

OL	Organic Silts & Organic Silty Clays Low Plasticity
ML	Inorganic Clayey Silts to & Very Fine Sands Slight Plasticity
CL	Inorganic Clays Low to Medium Plasticity
OH	Organic Clays & Silts Medium to High Plasticity
MH	Inorganic Silts & Clayey Silts High Plasticity
CH	Inorganic Clays High Plasticity

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

WC% = Water Content %

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Durham Phase #4 Expansion

PLASTICITY CHART

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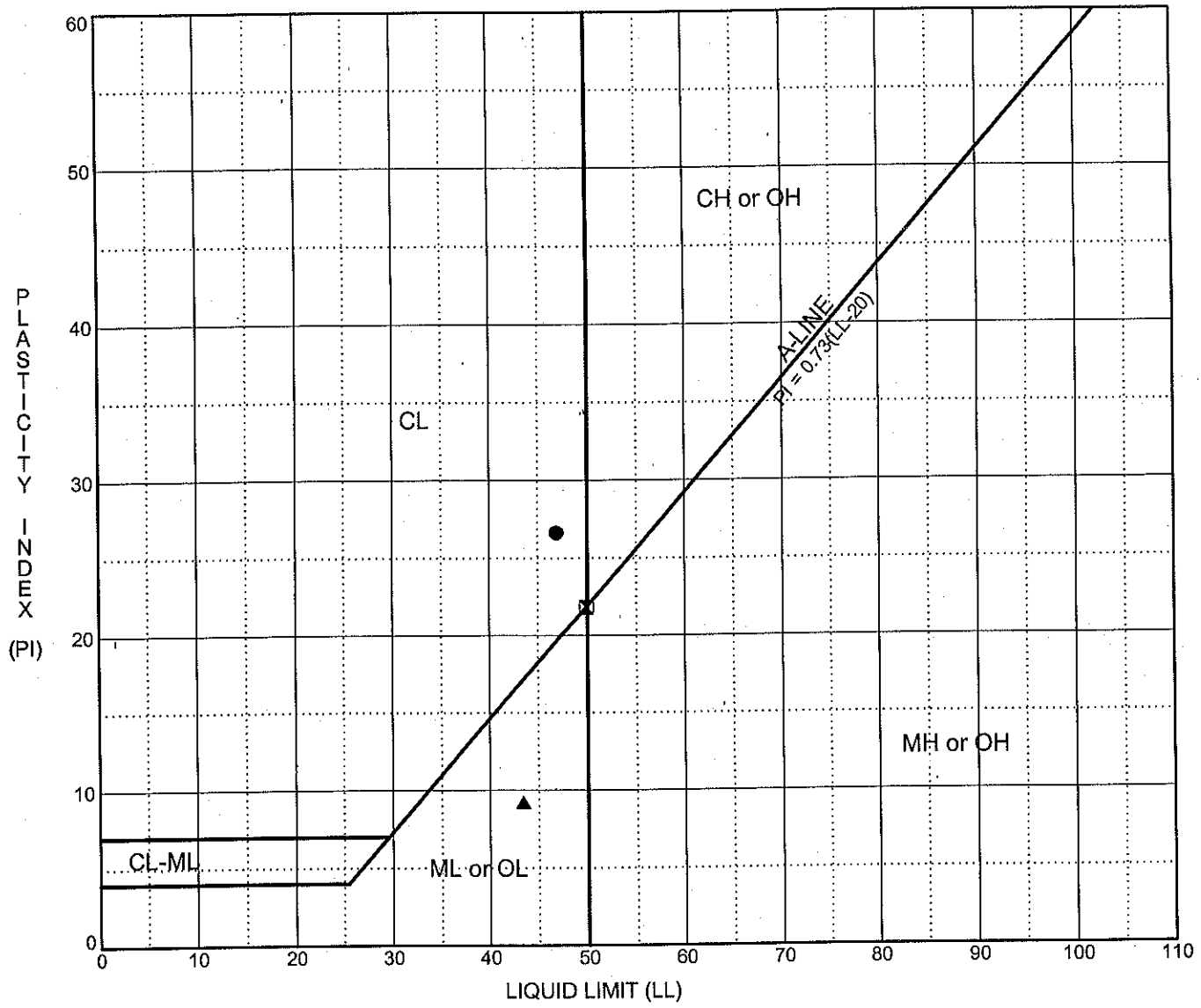
ATTERBERG

FIGURE C1



TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	LL	PL	PI	WC %	VISUAL-MANUAL CLASSIFICATION
● BH-10	S-7	34.0	CL	47	20	27	29.6	Grey brown silty CLAY
⊠ BH-10	S-13	59.0	ML/MH	50	28	22	34.9	Grey clayey SILT with trace sand
▲ BH-10	S-19	80.0	ML	43	34	9	41.5	Dark grey SILT with sand

NOTE: Atterberg Limits were performed on minus NO.40 sieve size material

GROUP Unified Soil Classification System (USCS) Fine-Grained Soil Groups

OL	Organic Silts & Organic Silty Clays Low Plasticity
ML	Inorganic Clayey Silts to & Very Fine Sands Slight Plasticity
CL	Inorganic Clays Low to Medium Plasticity
OH	Organic Clays & Silts Medium to High Plasticity
MH	Inorganic Silts & Clayey Silts High Plasticity
CH	Inorganic Clays High Plasticity

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

WC% = Water Content %

Durham Phase #4 Expansion

PLASTICITY CHART

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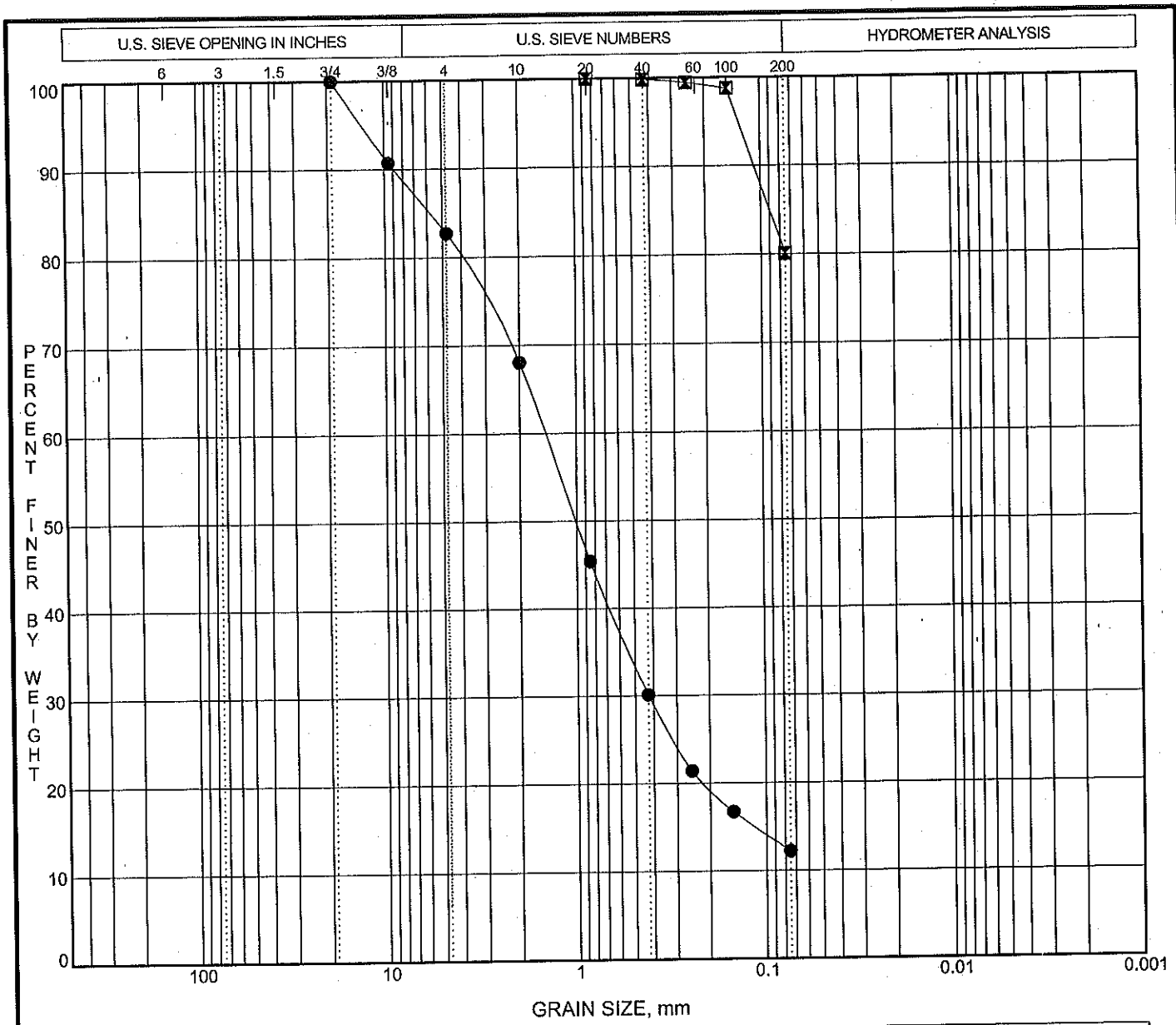
ATTERBERG 98394 802.GPJ NEWERTMP.GDT 12/18/03

ATTERBERG

FIGURE C2



COBBLES	GRAVEL		SAND			FINE-GRAINED SOIL	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZED	CLAY SIZED

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	WC %	Gravel %	Sand %	Fines %	VISUAL-MANUAL CLASSIFICATION
● BH-09	S-9	44.0	SP		17.3	70.5	12.2	Brown SAND with silt
⊠ BH-09	S-22	89.0	MH			20.0	80.0	Grey sandy clayey SILT

Durham Phase #4 Expansion

PARTICLE SIZE ANALYSIS (SIEVE TEST)

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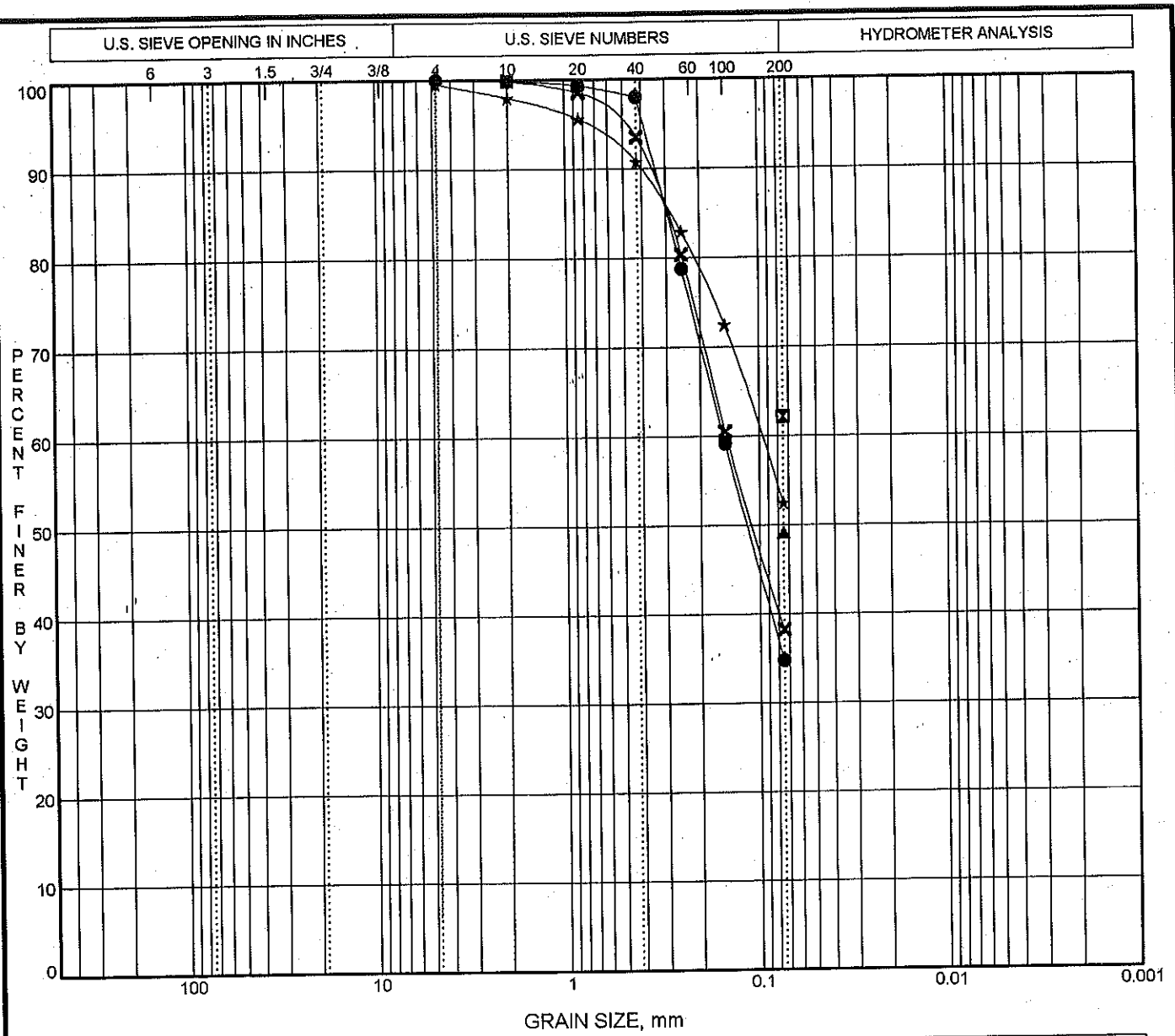
WC% = Water Content %

Reviewed 12-19

FIGURE C3

PARTICLE SIZE ANALYSIS 98394.802.GPJ NEWERTMP.GDT 12/18/03

PARTICLE SIZE ANALYSIS



COBBLES	GRAVEL		SAND			FINE-GRAINED SOIL	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZED	CLAY SIZED

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	WC %	Gravel %	Sand %	Fines %	VISUAL-MANUAL CLASSIFICATION
● BH-10	S-4	19.0	SM	37.9		65.2	34.8	Brown silty SAND
⊠ BH-10	S-9	39.0	CL	26.6			62.2	Grey and brown with rust mottling sandy silty CLAY
▲ BH-10	S-11	49.0	CL	35.8			49.1	Dark grey sandy silty CLAY
★ BH-10	S-12	55.0	ML/MH	38.6		47.0	52.5	Dark grey and brown sandy SILT
✕ BH-10	S-17	71.0	SM	34.3		61.6	38.3	Dark grey silty SAND

Durham Phase #4 Expansion

PARTICLE SIZE ANALYSIS (SIEVE TEST)

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WC% = Water Content %

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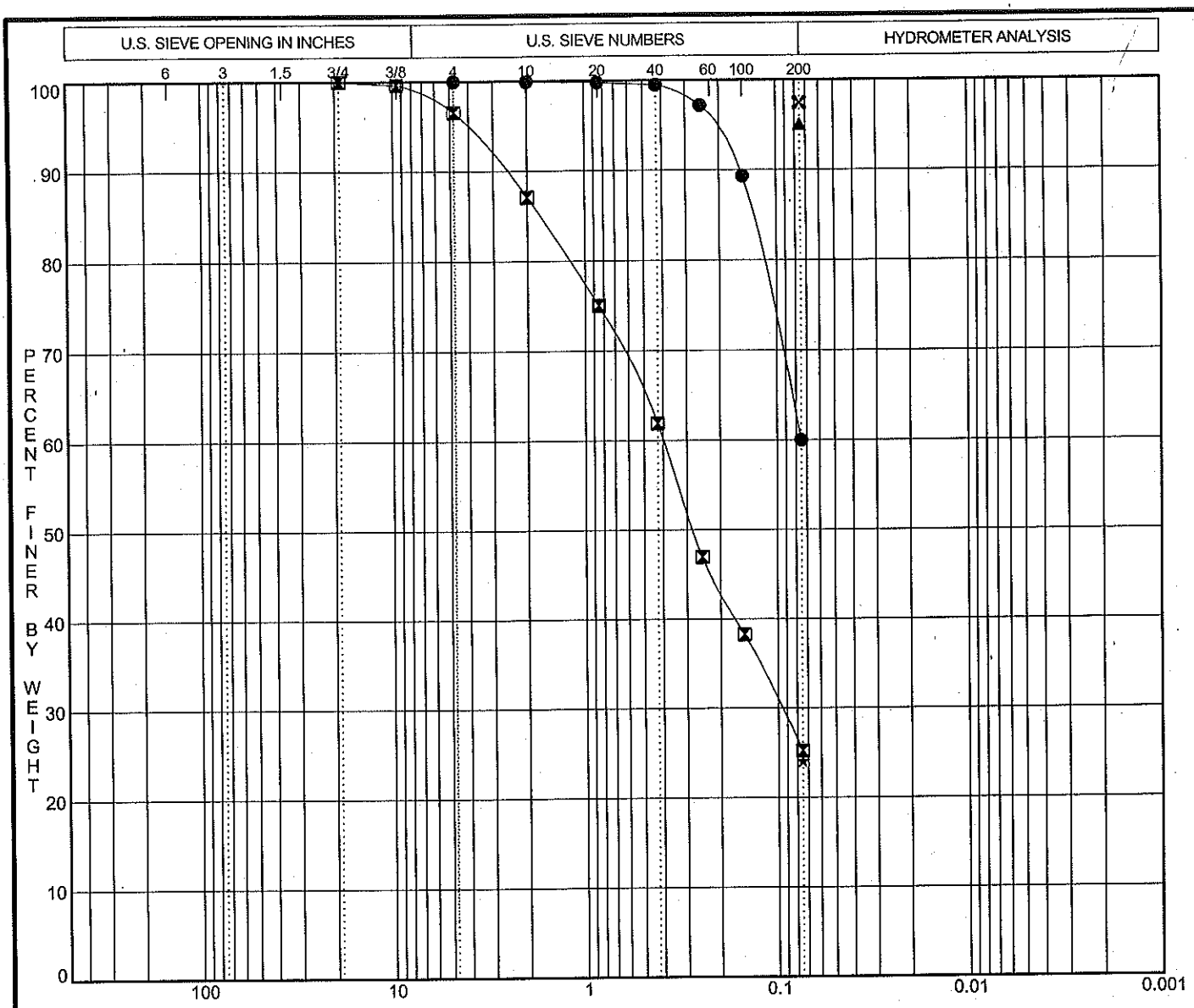
FIGURE C4

S_PARTICLE SIZE ANALYSIS 98394.802.GPJ NEWERTMP.GDT 2/12/04

S_PARTICLE SIZE ANALYSIS



COBBLES	GRAVEL		SAND			FINE-GRAINED SOIL	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZED	CLAY SIZED

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	WC %	Gravel %	Sand %	Fines %	VISUAL-MANUAL CLASSIFICATION
● BH-13	S-4	19.0	ML	40.5		40.0	60.0	Brown with rust mottling sandy SILT
⊠ BH-13	S-11	49.0	SM	36.0	3.4	71.3	25.2	Brown silty SAND
▲ BH-13	S-13	59.0	MH	37.5			95.0	Dark grey clayey SILT
★ BH-13	S-16A	69.0	SM	33.4			24.0	Light grey clayey silty SAND
✕ BH-13	S-16B	69.1	MH	36.8			97.4	Grey brown clayey SILT

Durham Phase #4 Expansion

PARTICLE SIZE ANALYSIS (SIEVE TEST)

SQUIER ASSOCIATES

98394.802

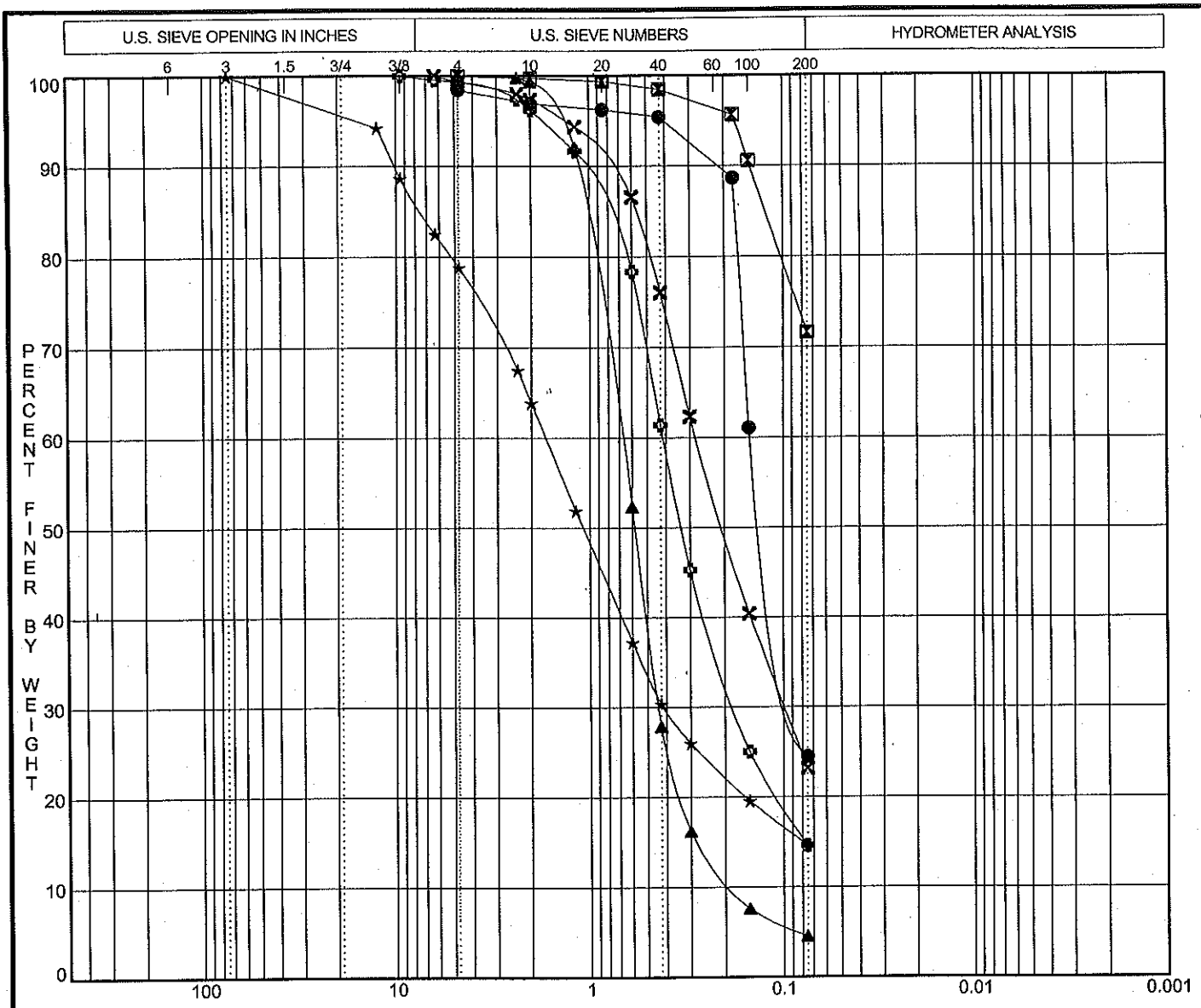
WC% = Water Content %

Reviewed

PARTICLE SIZE ANALYSIS

FIGURE C5

PARTICLE SIZE ANALYSIS 98394.802.GPJ NEWERTMP.GDT 12/18/03



COBBLES	GRAVEL		SAND			FINE-GRAINED SOIL	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZED	CLAY SIZED

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	WC %	Gravel %	Sand %	Fines %	VISUAL-MANUAL CLASSIFICATION
● BH-14	S-3	15.0	SM	25.3		74.0	24.5	Brown silty SAND
⊠ BH-15	S-5	21.0	ML	31.4		28.4	71.6	Brown sandy SILT
▲ BH-15	S-7	28.0	SP	38.6		95.5	4.5	Brown SAND with trace silt
★ BH-15	S-8	29.2	SM	16.9	21.2	64.2	14.6	Brown silty SAND with gravel
✕ BH-18	S-3	15.0	SM	22.8	0.6	76.2	23.1	Brown silty SAND
✪ BH-18	S-5	21.3	SM	27.0	0.7	84.7	14.6	Brown silty SAND

Durham Phase #4 Expansion

PARTICLE SIZE ANALYSIS (SIEVE TEST)

SQUIER ASSOCIATES

98394.802

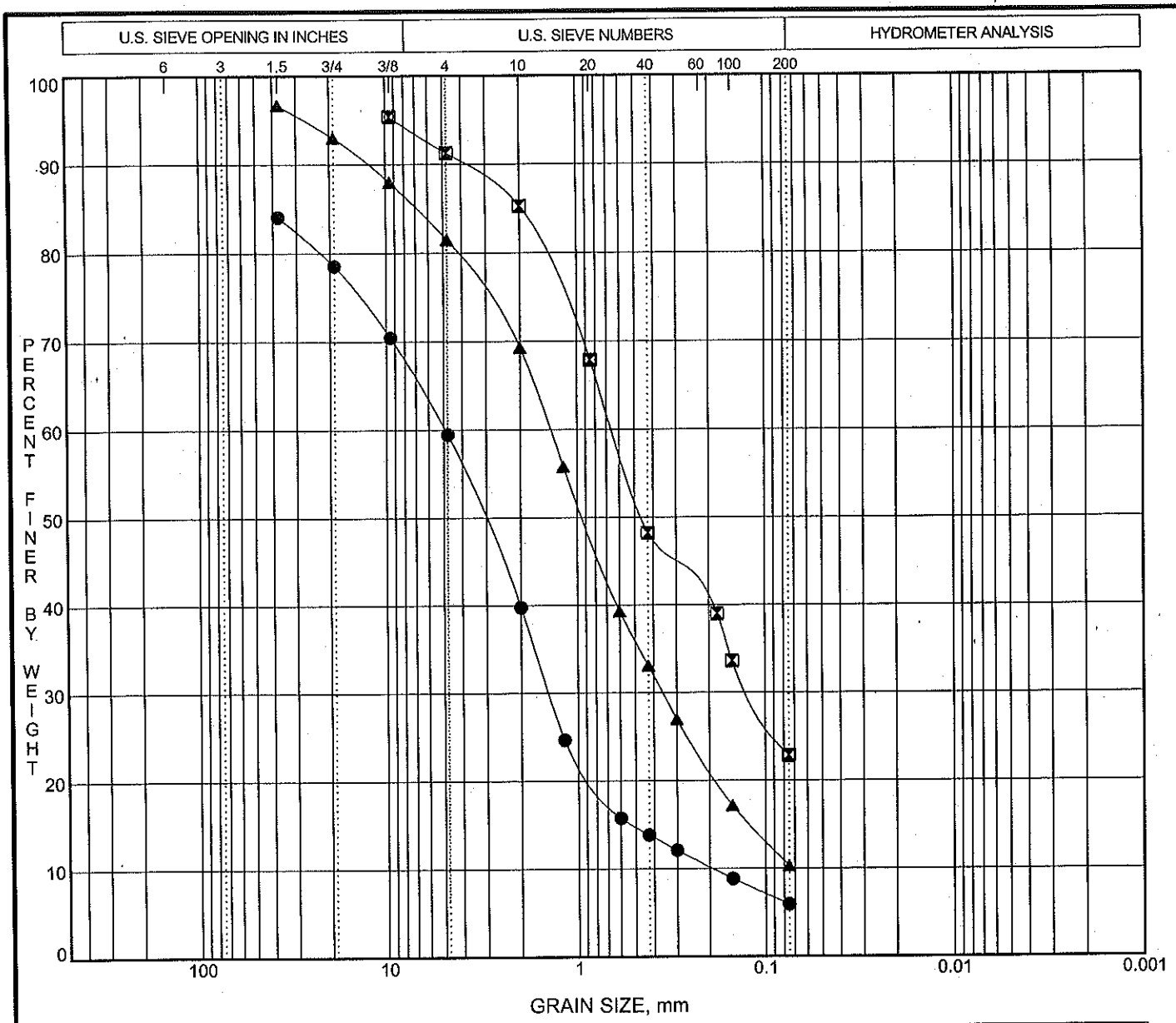
WC% = Water Content %

Reviewed

PARTICLE SIZE ANALYSIS

PARTICLE SIZE ANALYSIS 98394 802.GPJ NEWERTMP.GDT 12/18/03

FIGURE C6



COBBLES	GRAVEL		SAND			FINE-GRAINED SOIL	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZED	CLAY SIZED

TP-/B-	SAMPLE	DEPTH FT.	USCS UNIT	WC %	Gravel %	Sand %	Fines %	VISUAL-MANUAL CLASSIFICATION
● TP-1	S-2	23.0	SP	21.9	24.6	53.5	5.9	Orange brown gravelly SAND with trace fines
⊠ TP-2	S-1	15.0	SM	28.6	4.1	68.5	22.8	Brown silty SAND
▲ TP-3	S-1	16.0	SW-SM	27.4	15.2	71.2	10.3	Brown SAND with fines and gravel

Durham Phase #4 Expansion

PARTICLE SIZE ANALYSIS (SIEVE TEST)

SQUIER ASSOCIATES

98394.802

WC% = Water Content %

Reviewed

PARTICLE SIZE ANALYSIS

FIGURE C7

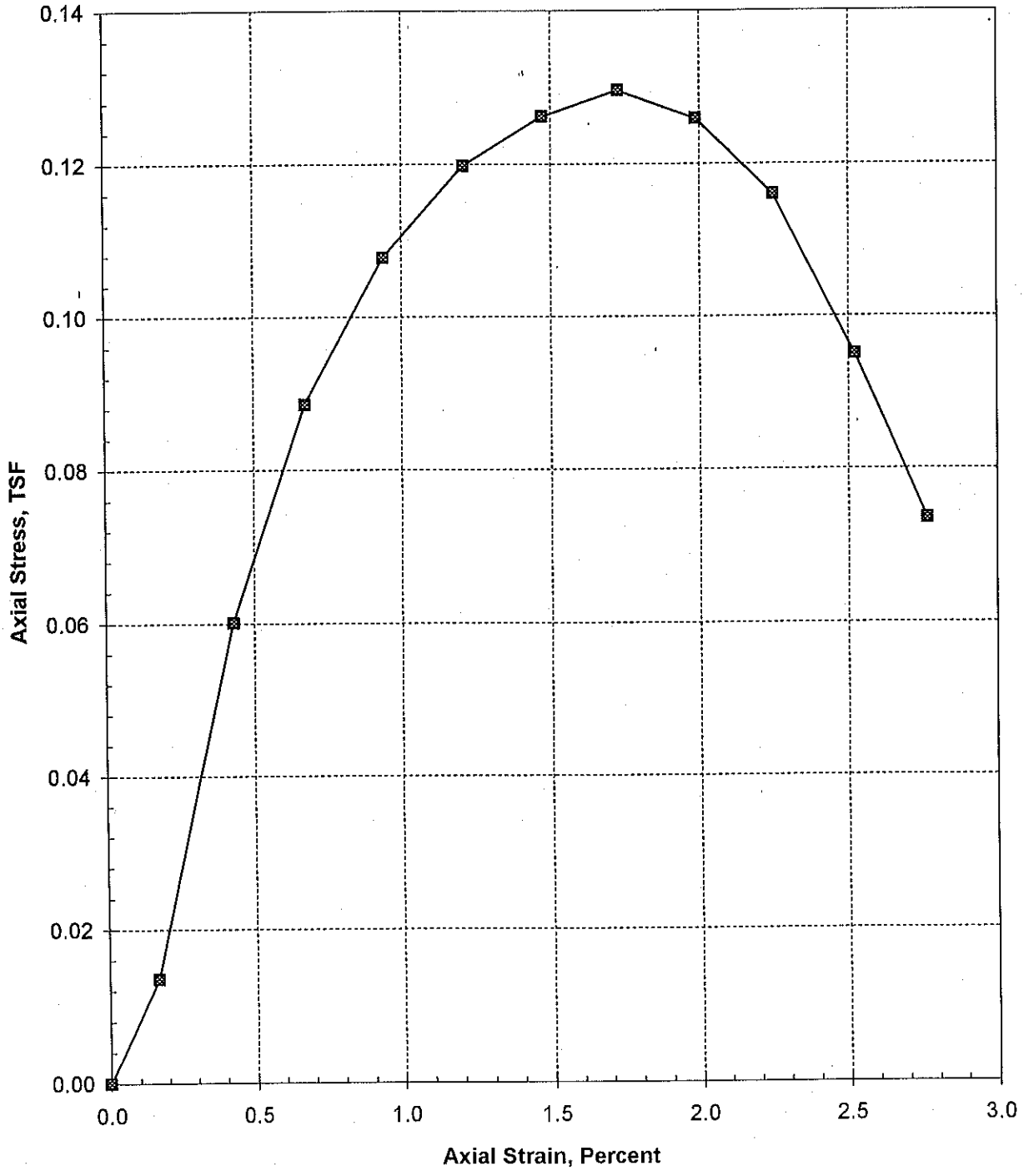
PARTICLE SIZE ANALYSIS 98394.802.GPJ NEWERTMP.GDT 12/18/03

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-9
Sample	S-19
Depth, ft.	79



SQUIER ASSOCIATES	PROJECT: Durham	Qu

Qu_B9-S19-79ft

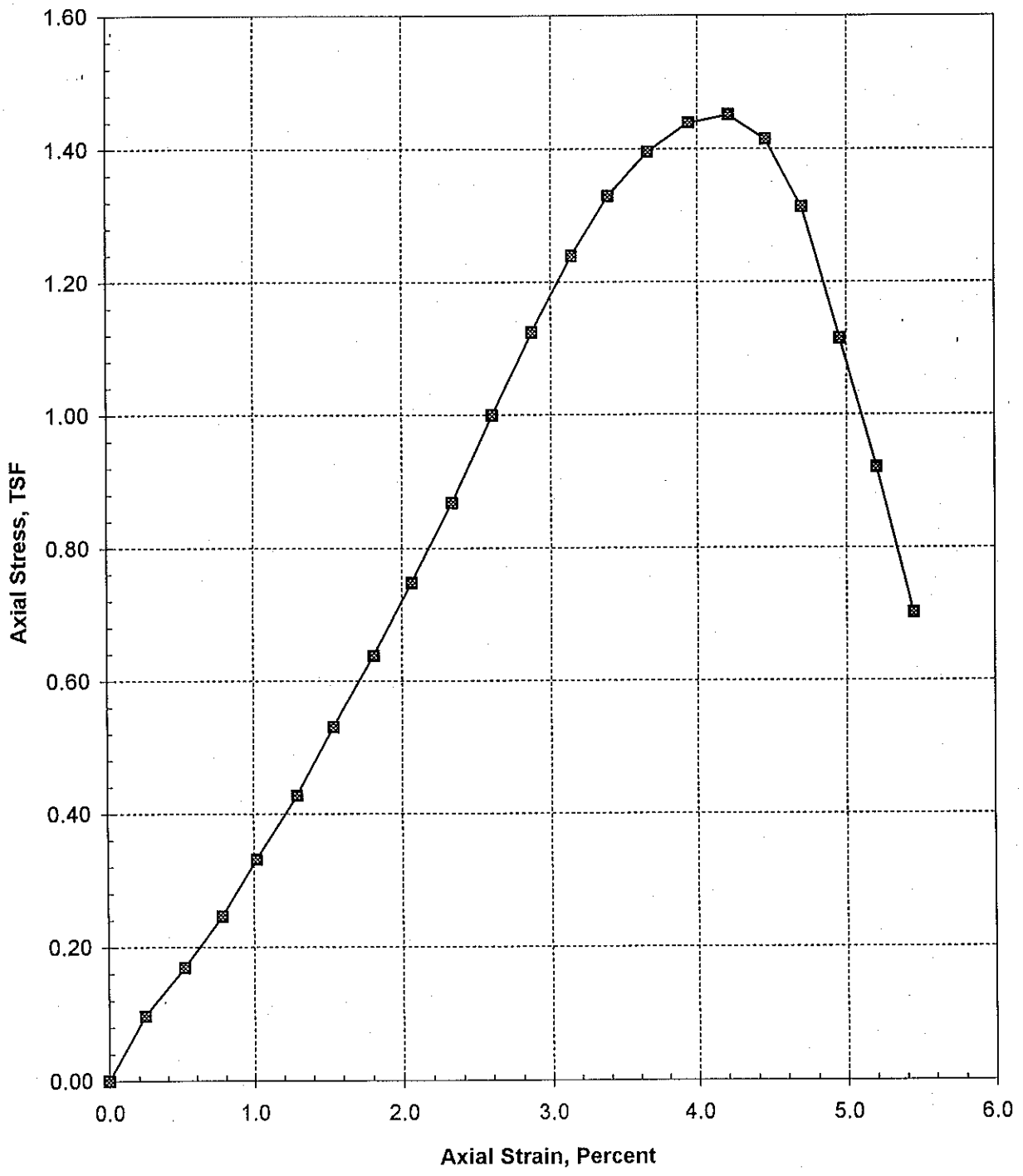
Figure C8

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-10
Sample	S-7
Depth, ft.	34



SQUIER ASSOCIATES	PROJECT: Durham	Qu

Qu_B10-S7-34ft

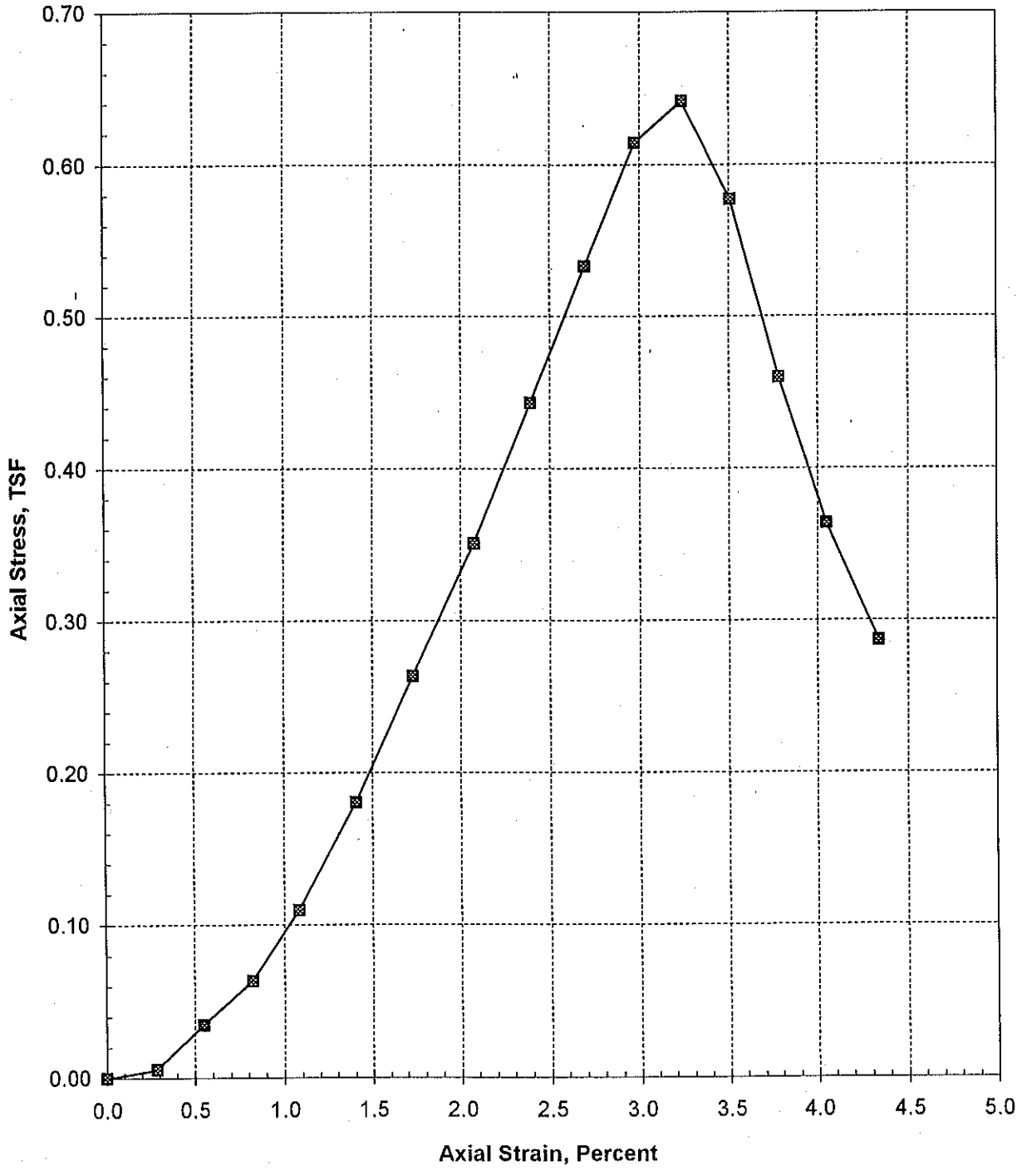
Figure C9

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-10
Sample	S-13
Depth, ft.	59



SQUIER ASSOCIATES	PROJECT: Durham	Qu

Qu_B10-S13-59

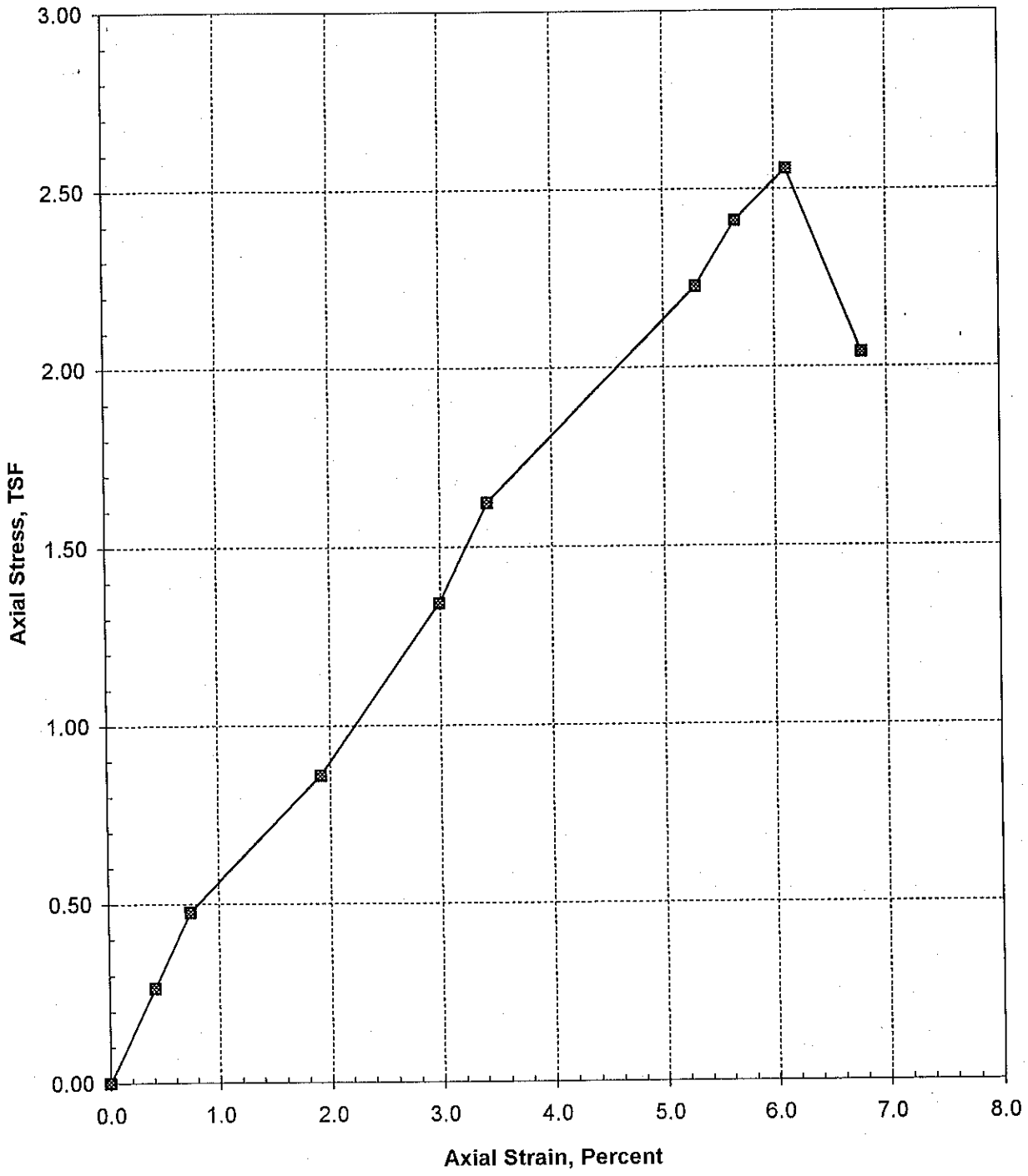
Figure C10

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B 11
Sample	S-6
Depth, ft.	29



SQUIER ASSOCIATES | PROJECT: Durham | Qu

Qu_B11-S6-29FT

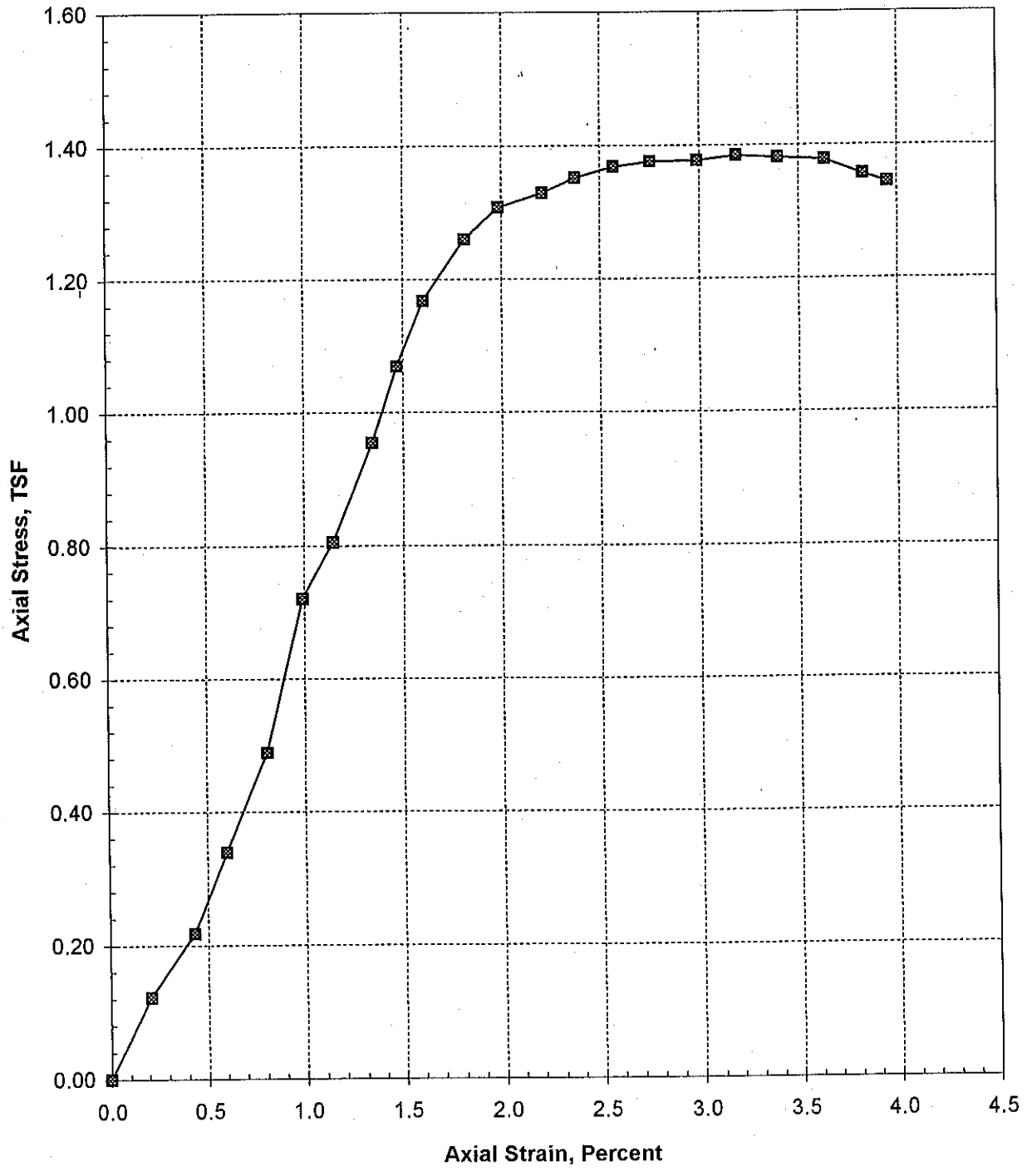
Figure C11

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-12
Sample	S-4
Depth, ft.	21



SQUIER ASSOCIATES | PROJECT: Durham | Qu

Qu_B12-S4-21FT

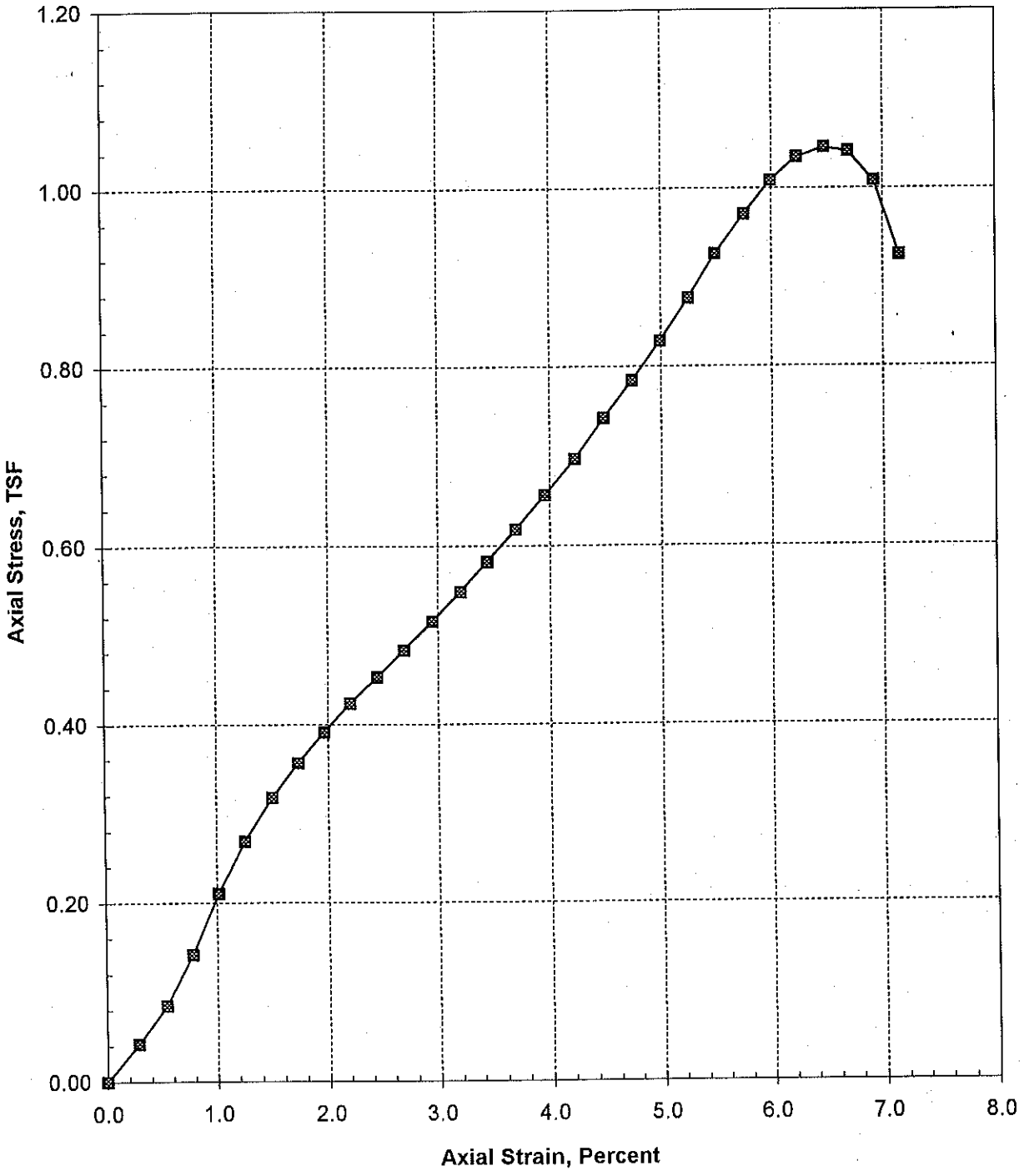
Figure C12

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-13
Sample	S-7
Depth, ft.	34



SQUIER ASSOCIATES K.M	PROJECT: Durham	Qu

Qu_B13-S7-34

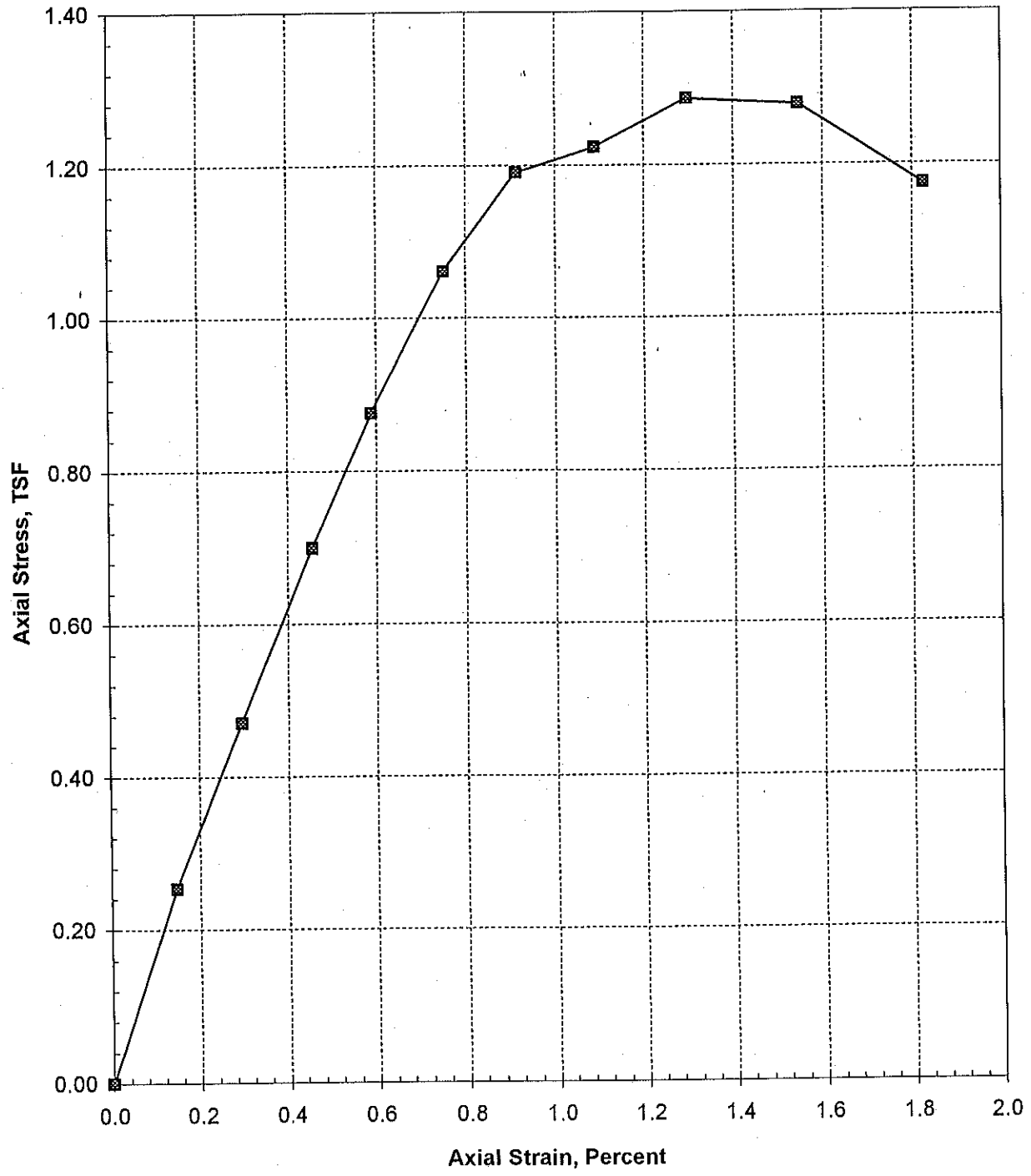
Figure C13

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98394.802
Boring/Test Pit	B-14
Sample	S-4
Depth, ft.	19



SQUIER ASSOCIATES	PROJECT: Durham	Qu

Qu_B14-S4-19FT

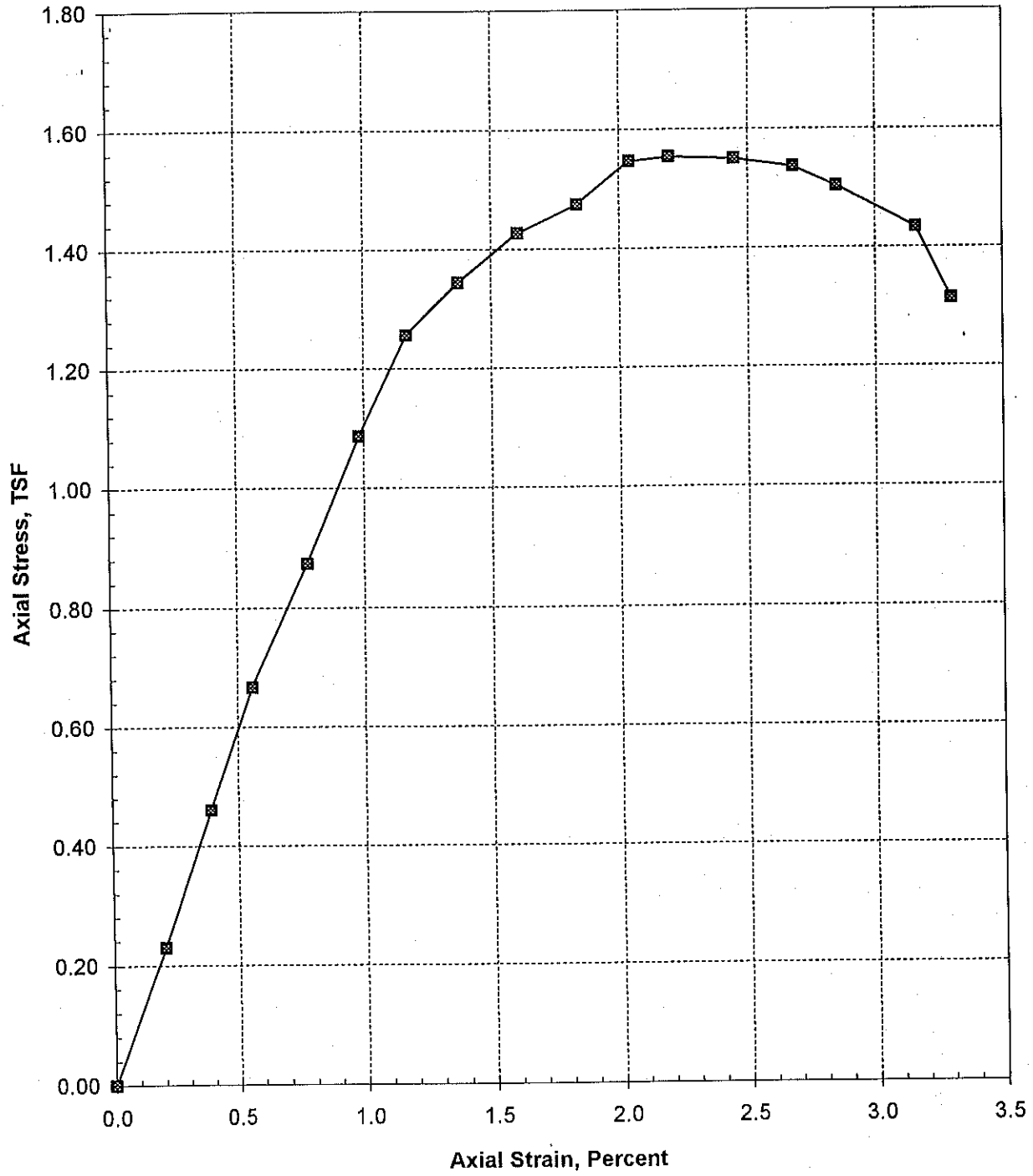
Figure C14

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

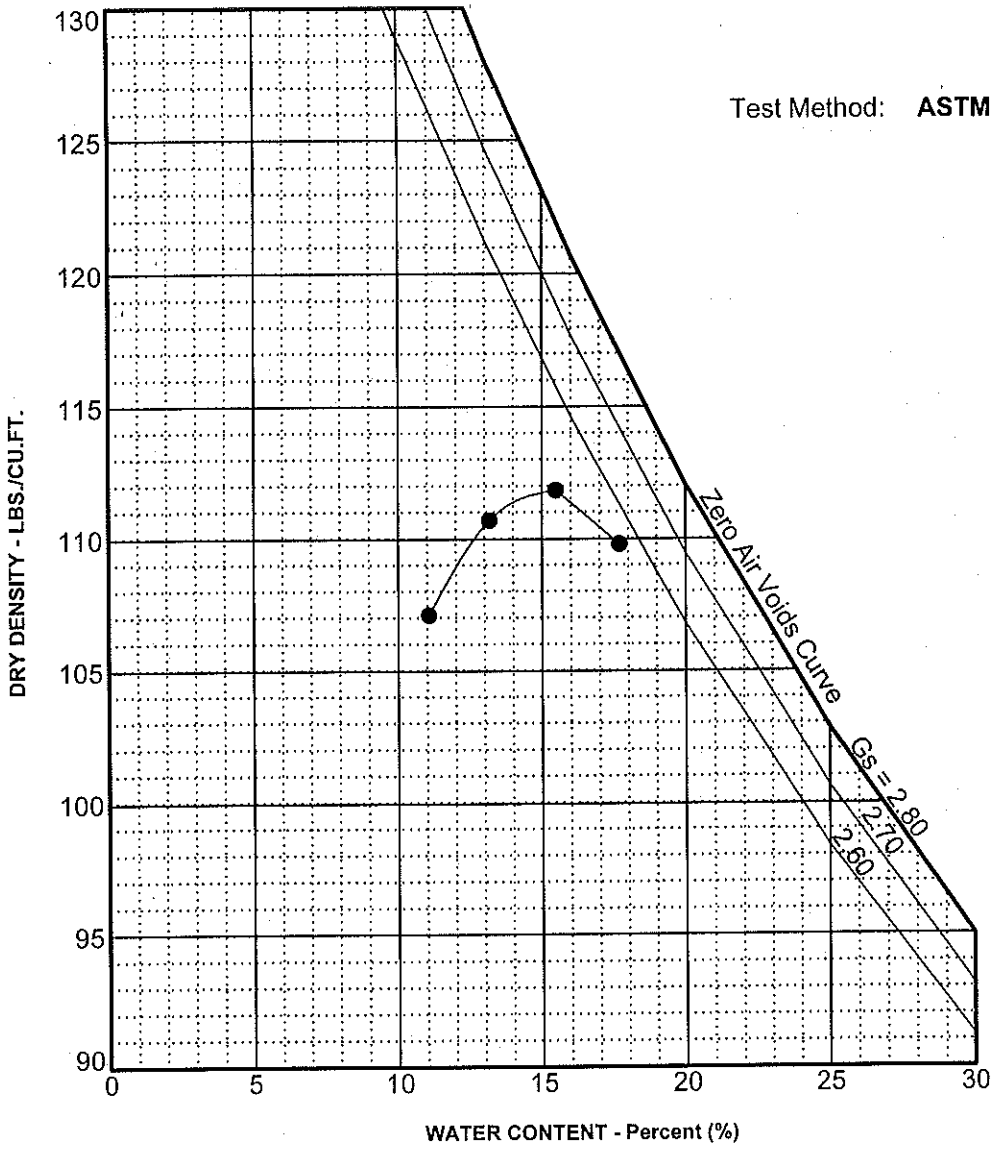
Job No.	98394.802
Boring/Test Pit	B-18
Sample	S-7
Depth, ft.	30



SQUIER ASSOCIATES	PROJECT: Durham	Qu

Qu_B18-S7-30FT

Figure C15



Test Symbol	TP/B	SAMPLE	DEPTH FT.	Optimum Wc (%)	Corrected* Max. Dry Density (lbs./cu.ft.)	CLASSIFICATION
●	TP-1	S-1	5	15.5	112	SILT with sand

Durham Phase #4 Expansion

COMPACTION TEST

SQUIER ASSOCIATES

98394.802

Reviewed

FIGURE C16

S_COMPACTION-SOIL 98394.802.GPJ NEWERTMP.GDT 2/13/04

S_COMPACTION-SOIL

RECEIVED
JAN 2 3 2004
SQUIER | KLEINFELDER

Cascade Corrosion Consulting Services, Inc.
P.O. Box 1248
Office: 503.435-0265
McMinnville, OR 97128
Fax: 503. 435-0266

January 21, 2004

OR354.04.01

Mr. Jerry Jacksha
Squier | Kleinfelder
15050 SW Knoll Parkway
Suite L
Beaverton, OR 97006

Subject: Soil Resistivity Measurements – Durham WWTP
Project Number 98394.806

Dear Jerry:

Cascade Corrosion Consulting Service, Inc. (CCCS) performed soil resistivity measurements on the four soil samples received from Squier | Kleinfelder on January 16, 2004. The measurements were authorized under your transmittal dated January 1, 2004.

The test measurements were performed using the soil box method as described in the ASTM standard G57-95a *Standard Test Method for Field Measurements of Soil Resistivity Using the Four-Electrode Method.* A two-pin soil box had to be used, instead of a four-pin soil box since the soil samples received was not large enough for the four-pin soil box. However, the two-pin box is a standard soil box for smaller samples and provides the same measurement as the four-pin box.

The meter and boxes used for the measurements are:

- Nelson Model 400 Soil Resistance Meter
- Agra Soil Box – Model Mark II

The results are shown in the attached data sheet.

Please do not hesitate to contact me at (503) 435-0265 or by e-mail at george.richards6@verizon.net, if you have any questions.

Sincerely,
Cascade Corrosion Consulting Service, Inc.

George E Richards

George Richards
Certified NACE International Corrosion Specialist #2083

Cascade Corrosion Consulting Services, Inc.
P.O. Box 1248
Office: 503.435-0265
McMinnville, OR 97128
Fax: 503. 435-0268

Client: Squier | Kleinfelder
Project Location: Durham WWTP
Project: Soil Resistivity Measurements

Date Samples Received: 1/16/2004
Date Samples Tested: 1/21/2004

Test Performed In Accordance to (standard): ASTM G57-95a standard
Standard Test Method for Field Measurement of Soil Resistivity Using the Wener Four -Electrode Method - (soil box method)

Measurement

No.	Boring No.	Sample No.	Depth (ft)	Date Extracted	As Received			Saturated[1]		
					Resistance (ohm)	Soil Box Factor	Resistivity (ohm-cm)	Resistance (ohm)	Soil Box Factor	Resistivity (ohm-cm)
1	BH-9	S-5	24	Unknown	1,900	10	19,000	1,700	10	17,000
2	BH-17	S-1	5	9/30/2003	2,200	10	22,000	1,100	10	11,000
3	BH-18	S-1	5	9/30/2003	670	10	6,700	550	10	5,500
4	BH-18	S-6	25	9/30/2003	290	10	2,900	210	10	2,100

Note: (1) Saturation performed using distilled water

Meter Used: Nelson Model 400 Soil Resistance Meter
Soil Box Used: Agra Soil Box - Model Mark II

Test Perfromed By: George Richards
Certified NACE International Corrosion Specialist #2083
Expires 1/1/05

Soil Box Resistivity

Environmental Services Laboratory, Inc.

E S L

17400 SW Upper Boones Ferry Road, Suite 270 • Portland, OR 97224 • (503) 670-8520

January 08, 2004

Jerry Jacksha
Squier Associates
4260 Galewood St.
Lake Oswego, OR 97035-2405

TEL: (503) 635-4419
FAX (503) 635-1430

RE:

Order No.: 0312096

Dear Jerry Jacksha:

Environmental Services Laboratory received 4 samples on 12/10/03 for the analyses presented in the following report.

There were no analytical problems encountered and all analytical data met requirements established under NELAC protocol or laboratory specifications except where noted in a Case Narrative. Results apply only to the samples analyzed. Reproduction of this report is permitted only in its entirety, without the written approval of the laboratory. The following checked data sections are included in this report.

✓Base Sample Report ✓Method Blank Report ✓Sample Duplicate Report ✓Matrix Spike/Matrix Spike Duplicate Report ✓Laboratory Control Spike/Spike Duplicate Report ✓Continuing Calibration Verification Report __Initial Calibration Verification Report

If you have any questions regarding these tests results, please feel free to call.

Darwin Thomas
Project Manager

Keith Hunter
Technical Review

Case Narrative

ESL ID # : 0312096 Dec. 26, 2003

On 12/10/03, samples 0312096-01 through -04 were submitted to ESL for analysis of conductivity. There is no laboratory method for conductivity/resistivity of soil. The method that is performed at ESL is EPA 120.1, Specific Conductance, which states:

"This method is applicable to drinking, surface, and saline water, domestic and industrial wastes and acid rain (atmospheric deposition)."

Soil resistivity should be measured in situ, or in the field. There is no way to ascertain how the conductivity/resistivity of the soil is affected by removing the sample from the ground and transporting it to the laboratory. Furthermore, any result that the laboratory generates would be meaningless because Method 120.1 is intended only for aqueous (water) samples.

Please do not hesitate to call if there are any questions, or if we can be of further assistance in this project. Thank you.

Jason Adams
General Chemistry Analyst

Environmental Services Laboratory

Date: *08-Jan-04*

CLIENT: Squier Associates
Lab Order: 0312096
Project:
Lab ID: 0312096-01A

Client Sample ID: BH-9 S-5
Tag Number:
Collection Date: 12/10/03
Matrix: SOIL

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY		**EPA 300.0**				Analyst: **jca**
Chloride	ND	20.0		mg/L	1	12/11/03
Sulfate	ND	100		mg/L	1	12/11/03
PH		**EPA 150.1**				Analyst: **jca**
pH	6.0	0		pH units	1	12/11/03 4:30:00 PM

Qualifiers:

ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds Maximum Contaminant Level
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
E - Value above quantitation range

Environmental Services Laboratory

Date: *08-Jan-04*

CLIENT:	Squier Associates	**Client Sample ID:**	BH-17 S-1
Lab Order:	0312096	**Tag Number:**	
Project:		**Collection Date:**	12/10/03
Lab ID:	0312096-02A	**Matrix:**	SOIL

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY		**EPA 300.0**				Analyst: jca
Chloride	ND	20.0		mg/L	1	12/11/03
Sulfate	ND	100		mg/L	1	12/11/03
PH		**EPA 150.1**				Analyst: jca
pH	5.3	0		pH units	1	12/11/03 4:30:00 PM

Qualifiers:

ND - Not Detected at the Reporting Limit

J - Analyte detected below quantitation limits

B - Analyte detected in the associated Method Blank

* - Value exceeds Maximum Contaminant Level

S - Spike Recovery outside accepted recovery limits

R - RPD outside accepted recovery limits

E - Value above quantitation range

Environmental Services Laboratory

Date: *08-Jan-04*

CLIENT:	Squier Associates	**Client Sample ID:**	BH-18 S-1
Lab Order:	0312096	**Tag Number:**	
Project:		**Collection Date:**	12/10/03
Lab ID:	0312096-03A	**Matrix:**	SOIL

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY		**EPA 300.0**				Analyst: **jca**
Chloride	ND	20.0		mg/L	1	12/11/03
Sulfate	109	100		mg/L	1	12/11/03
PH		**EPA 150.1**				Analyst: **jca**
pH	5.4	0		pH units	1	12/11/03 4:30:00 PM

Qualifiers:

ND - Not Detected at the Reporting Limit

J - Analyte detected below quantitation limits

B - Analyte detected in the associated Method Blank

* - Value exceeds Maximum Contaminant Level

S - Spike Recovery outside accepted recovery limits

R - RPD outside accepted recovery limits

E - Value above quantitation range

Environmental Services Laboratory

Date: *08-Jan-04*

CLIENT:	Squier Associates	**Client Sample ID:**	BH-18 S-6
Lab Order:	0312096	**Tag Number:**	
Project:		**Collection Date:**	12/10/03
Lab ID:	0312096-04A	**Matrix:**	SOIL

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY		**EPA 300.0**				Analyst: **jca**
Chloride	ND	20.0		mg/L	1	12/11/03
Sulfate	ND	100		mg/L	1	12/11/03
PH		**EPA 150.1**				Analyst: **jca**
pH	7.2	0		pH units	1	12/11/03 4:30:00 PM

Qualifiers:

ND - Not Detected at the Reporting Limit

J - Analyte detected below quantitation limits

B - Analyte detected in the associated Method Blank

* - Value exceeds Maximum Contaminant Level

S - Spike Recovery outside accepted recovery limits

R - RPD outside accepted recovery limits

E - Value above quantitation range

CLIENT: Squier Associates
Work Order: 0312096
Project:

ANALYTICAL QC SUMMARY REPORT

TestCode: 01 IC ANIONS

Sample ID: **MBLK** SampType: **MBLK** TestCode: **01 IC ANIONS** Units: **mg/L** Prep Date: **12/11/03** Run ID: **CRANE_031211A**
Client ID: **ZZZZZ** Batch ID: **R15652** TestNo: **EPA 300.0** Analysis Date: **12/11/03** SeqNo: **189691**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.400									
Sulfate	ND	2.00									

Sample ID: **LCS** SampType: **LCS** TestCode: **01 IC ANIONS** Units: **mg/L** Prep Date: **12/11/03** Run ID: **CRANE_031211A**
Client ID: **ZZZZZ** Batch ID: **R15652** TestNo: **EPA 300.0** Analysis Date: **12/11/03** SeqNo: **189693**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.01	0.400	5	0	100	85	115	0	0		
Sulfate	22.6	2.00	25	0	90.4	85	115	0	0		

Sample ID: **LCSD** SampType: **LCSD** TestCode: **01 IC ANIONS** Units: **mg/L** Prep Date: **12/11/03** Run ID: **CRANE_031211A**
Client ID: **ZZZZZ** Batch ID: **R15652** TestNo: **EPA 300.0** Analysis Date: **12/11/03** SeqNo: **189694**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	4.95	0.400	5	0	99	85	115	5.01	1.20	20	
Sulfate	22.5	2.00	25	0	90	85	115	22.6	0.443	20	

Sample ID: **0312096-04A MS** SampType: **MS** TestCode: **01 IC ANIONS** Units: **mg/L** Prep Date: **12/11/03** Run ID: **CRANE_031211A**
Client ID: **BH-18 S-6** Batch ID: **R15652** TestNo: **EPA 300.0** Analysis Date: **12/11/03** SeqNo: **189701**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	101	20.0	100	0	101	75	125	0	0		
Sulfate	178	100	200	0	89	75	125	0	0		

Sample ID: **0312096-04A MSD** SampType: **MSD** TestCode: **01 IC ANIONS** Units: **mg/L** Prep Date: **12/11/03** Run ID: **CRANE_031211A**
Client ID: **BH-18 S-6** Batch ID: **R15652** TestNo: **EPA 300.0** Analysis Date: **12/11/03** SeqNo: **189702**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	99.3	20.0	100	0	99.3	75	125	101	1.70	20	

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: Squier Associates
Work Order: 0312096
Project:

ANALYTICAL QC SUMMARY REPORT

TestCode: 01 IC ANIONS

Sample ID: 0312096-04A MSD	SampType: MSD	TestCode: 01 IC ANIONS	Units: mg/L	Prep Date: 12/11/03	Run ID: CRANE_031211A
Client ID: BH-18 S-6	Batch ID: R15652	TestNo: EPA 300.0		Analysis Date: 12/11/03	SeqNo: 189702

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	176	100	200	0	88	75	125	178	1.13	20	

Sample ID: 0311198-01A DUP	SampType: DUP	TestCode: 01 IC ANIONS	Units: mg/L	Prep Date: 12/11/03	Run ID: CRANE_031211A
Client ID: ZZZZZ	Batch ID: R15652	TestNo: EPA 300.0		Analysis Date: 12/11/03	SeqNo: 189696

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	20.0	0	0	0	0	0	0	0	20	
Sulfate	ND	100	0	0	0	0	0	0	0	20	

Sample ID: CCV	SampType: CCV	TestCode: 01 IC ANIONS	Units: mg/L	Prep Date: 12/11/03	Run ID: CRANE_031211A
Client ID: ZZZZZ	Batch ID: R15652	TestNo: EPA 300.0		Analysis Date: 12/11/03	SeqNo: 189692

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	4.16	0.400	4	0	104	90	110	0	0		
Sulfate	9.35	2.00	10	0	93.5	90	110	0	0		

Sample ID: CCV	SampType: CCV	TestCode: 01 IC ANIONS	Units: mg/L	Prep Date: 12/11/03	Run ID: CRANE_031211A
Client ID: ZZZZZ	Batch ID: R15652	TestNo: EPA 300.0		Analysis Date: 12/11/03	SeqNo: 189703

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.73	0.400	8	0	96.6	90	110	0	0		
Sulfate	18.1	2.00	20	0	90.5	90	110	0	0		

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: Squier Associates
Work Order: 0312096
Project:

ANALYTICAL QC SUMMARY REPORT

TestCode: 01 PH S

Sample ID: 0312096-01A DUP	SampType: DUP	TestCode: 01 PH S	Units: pH units	Prep Date: 12/11/03	Run ID: NO INST_031211C
Client ID: BH-9 S-5	Batch ID: R15646	TestNo: EPA 150.1		Analysis Date: 12/11/03	SeqNo: 189585

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	6	0	0	0	0	0	0	6	0	6	

Sample ID: CCV	SampType: CCV	TestCode: 01 PH S	Units: pH units	Prep Date: 12/11/03	Run ID: NO INST_031211C
Client ID: ZZZZZ	Batch ID: R15646	TestNo: EPA 150.1		Analysis Date: 12/11/03	SeqNo: 189583

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	6.01	0	6	0	100	97	103	0	0		

Sample ID: CCV	SampType: CCV	TestCode: 01 PH S	Units: pH units	Prep Date: 12/11/03	Run ID: NO INST_031211C
Client ID: ZZZZZ	Batch ID: R15646	TestNo: EPA 150.1		Analysis Date: 12/11/03	SeqNo: 189589

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	7.97	0	8	0	99.6	97	103	0	0		

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

Appendix E
GEOPROBE OBSERVATION WELLS

APPENDIX E
GEOPROBE OBSERVATION WELLS

General

A total of six (6) observation wells were installed in October 2003 in vicinity of the deep influent facilities at locations shown on Drawings GEO DATA-2 through GEO DATA-4. The observation wells are designated OW-1 through OW-6, and are shown in this appendix on Figures E1 through E6. The wells were constructed as 10-foot long "prepack" well screen with 0.010-inch slots and 1.5-inch inside diameter. The riser pipe was 1.5-inch diameter schedule 40 PVC Pipe. The probe hole was advanced with using a truck-mounted Geoprobe 6600 rig provided and operated by Geo-Tech Explorations, Inc, Tualatin, Oregon. Soil recovery was done at the bottom of the hole only to confirm that the bottom of the well was set at the contact between the Flood Deposits (Younger Alluvium) and the Valley Fill (Lower Alluvium). The well was covered with an above ground locking steel casing. Each of the geoprobe advancements and well installations were observed by our field representative who maintained a log of the well installation.

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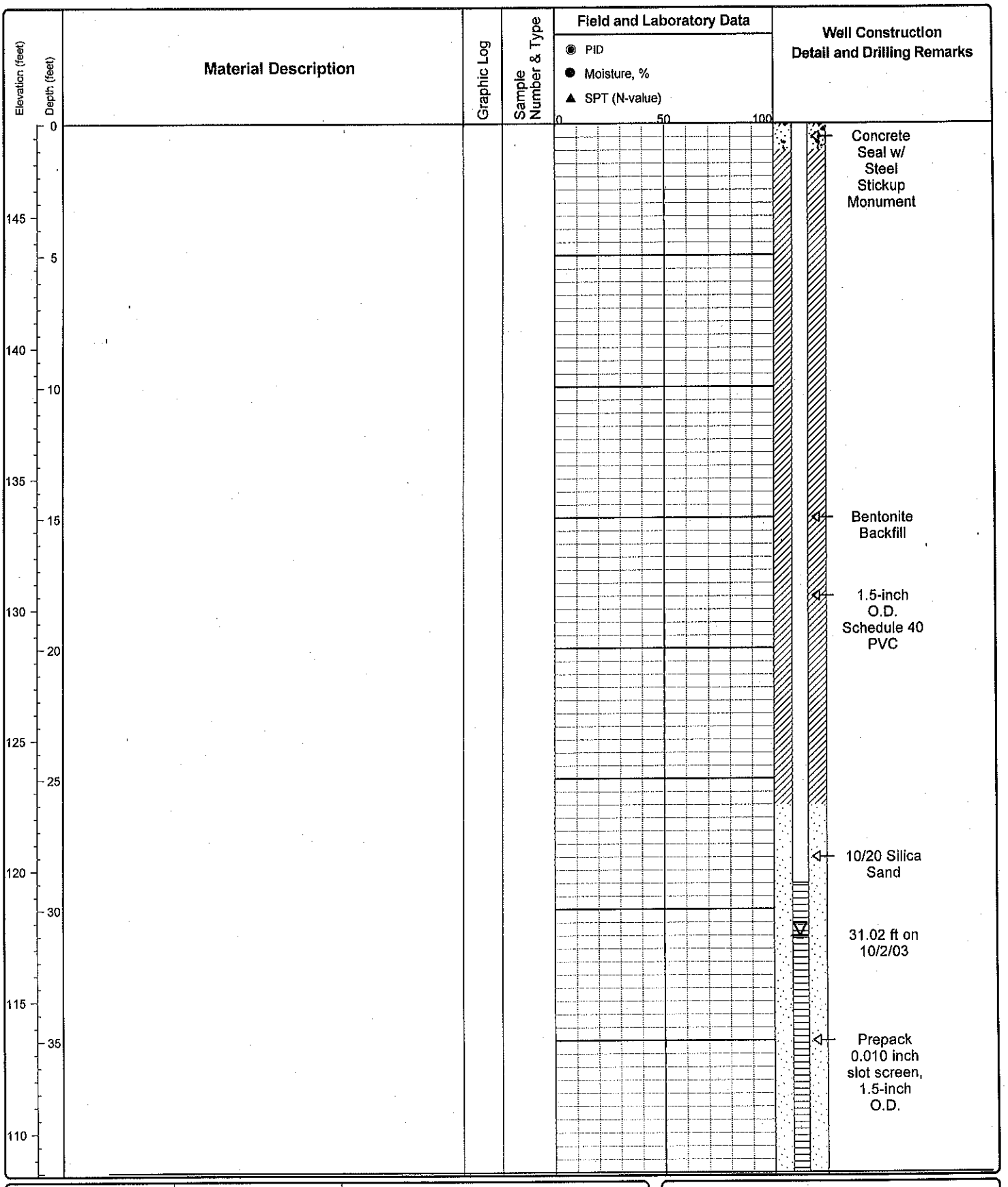

Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-1 Printed: 2/12/04

Date Drilling Started: 10/2/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 50.0	Station:	Offset:
Surface Elevation (ft): 148.5	Elevation Datum (ft.)	Coordinates: N 639740.0	E 7620070.8

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

GEOPROBE OW-1

Project No. 98394.802

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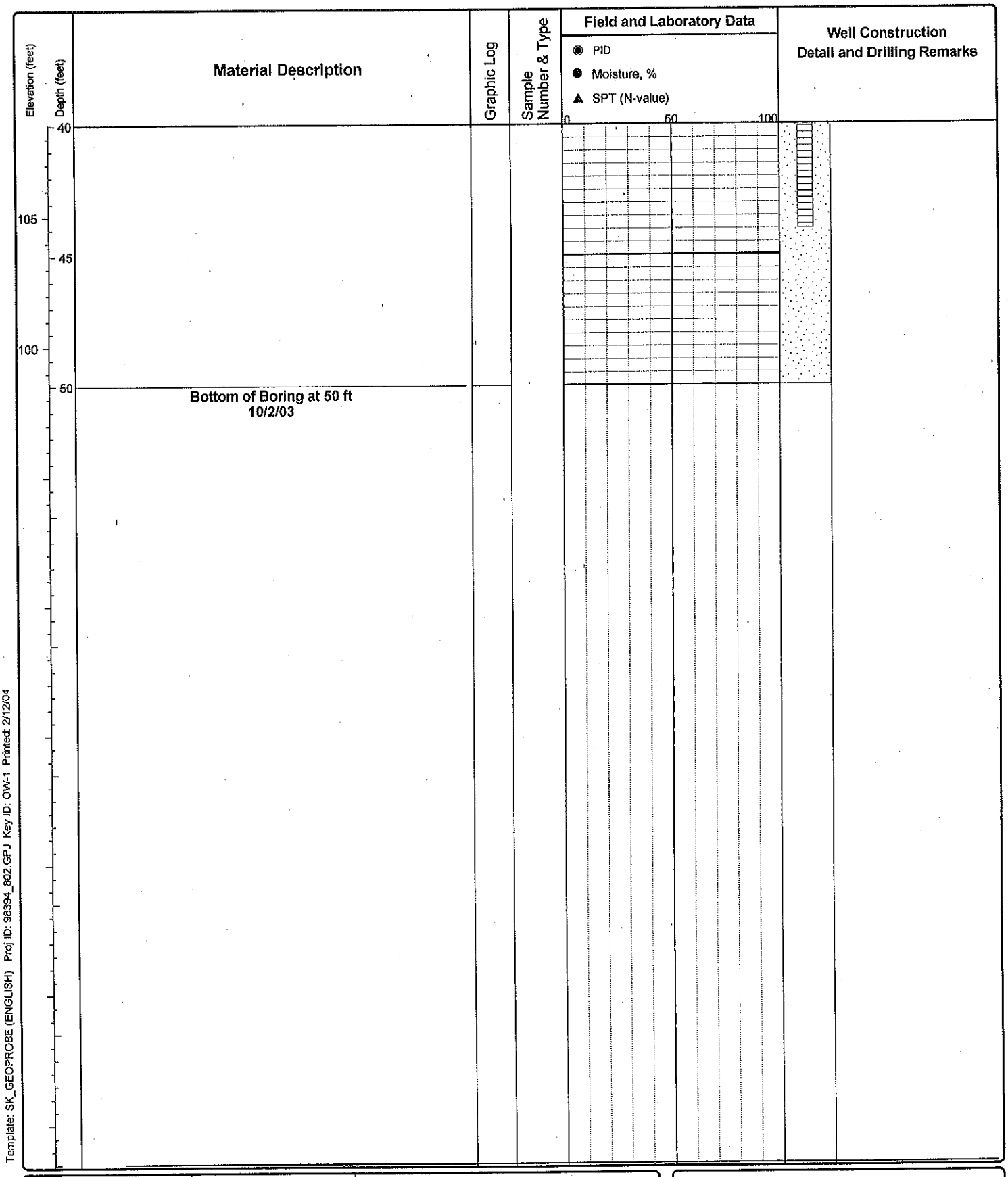
(Sheet 1 of 2)

FIGURE E1



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-1 Printed: 2/12/04

Date Drilling Started: 10/2/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 50.0	Station:	Offset:
Surface Elevation (ft): 148.5	Elevation Datum (ft.)	Coordinates: N 639740.0	E 7620070.8

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

GEOPROBE OW-1

Project No. 98394.802

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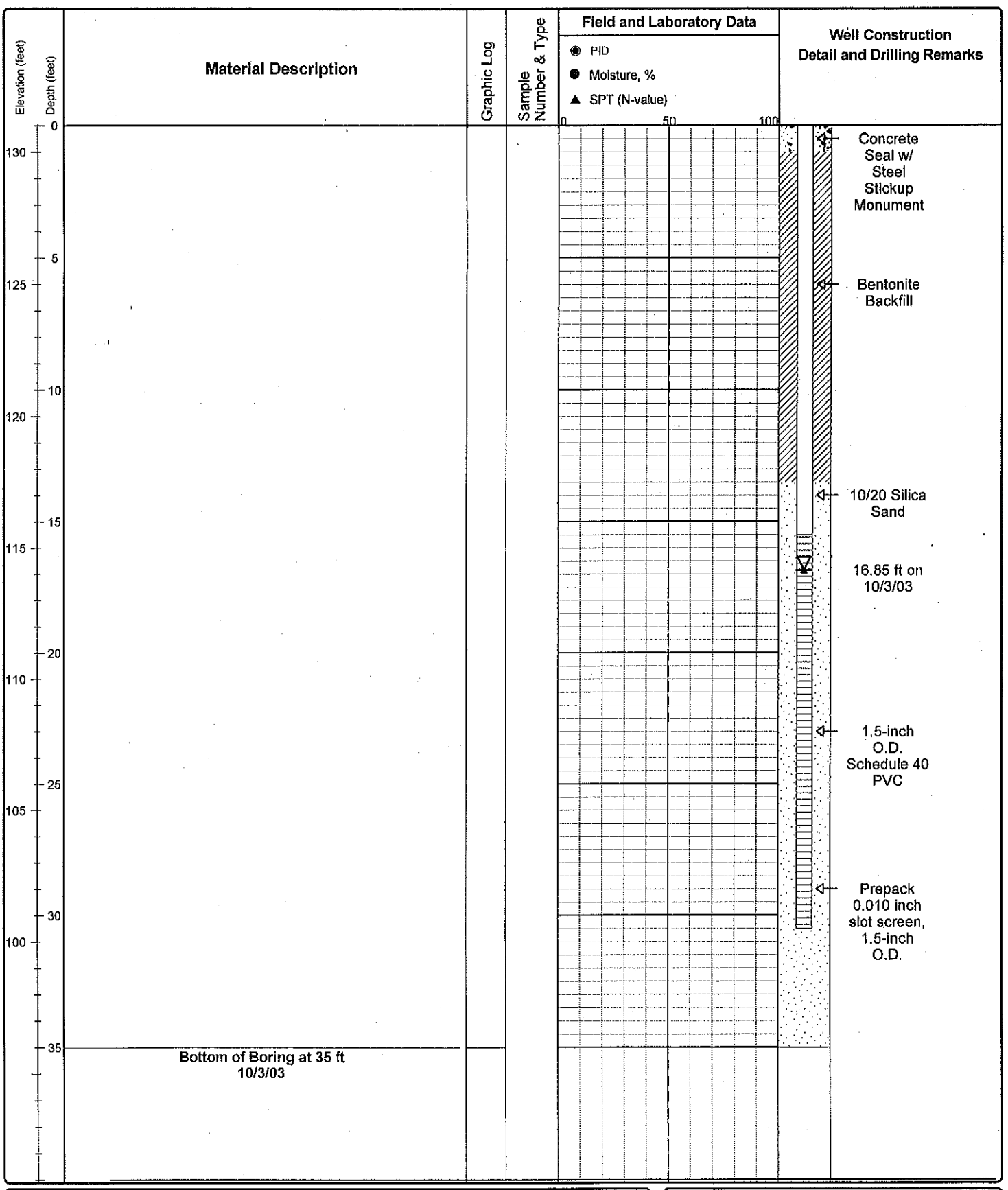
(Sheet 2 of 2)

FIGURE E1



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-2 Printed: 2/12/04

Date Drilling Started: 10/3/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 35.0	Station:	Offset:
Surface Elevation (ft): 131.0	Elevation Datum (ft.)	Coordinates: N 639647.3	E 7620074.0

Durham Phase #4 Expansion

GEOPROBE OW-2

Project No. 98394.802

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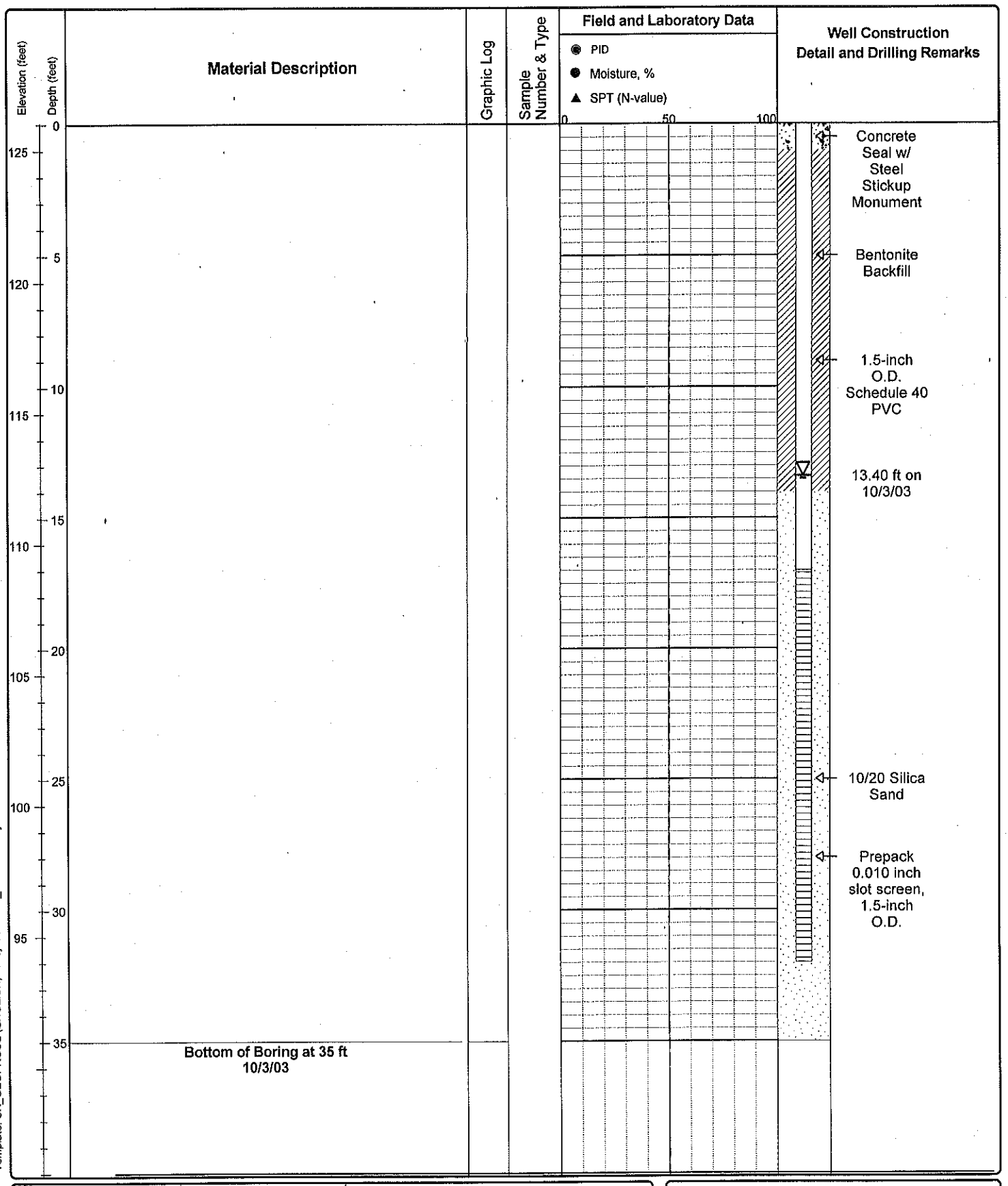
(Sheet 1 of 1)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

FIGURE E2



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-3 Printed: 2/12/04

Date Drilling Started: 10/3/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 35.0	Station:	Offset:
Surface Elevation (ft): 126.0	Elevation Datum (ft.)	Coordinates: N 639564.9	E 7620162.2

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

GEOPROBE OW-3

Project No. 98394.802

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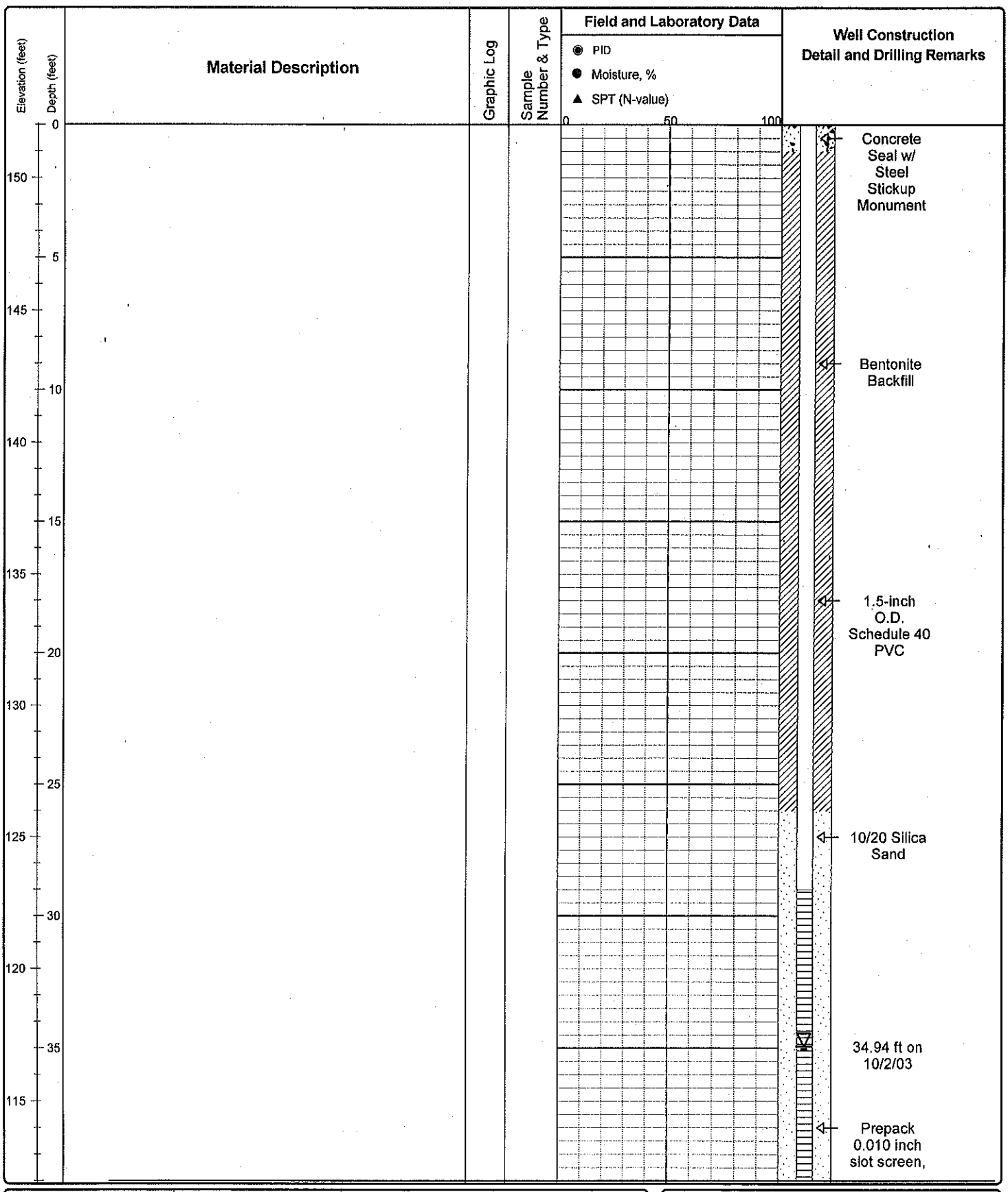
(Sheet 1 of 1)

FIGURE E3



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-4 Printed: 2/12/04

Date Drilling Started: 10/2/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 50.0	Station:	Offset:
Surface Elevation (ft): 152.0	Elevation Datum (ft.)	Coordinates: N 639782.0	E 7619913.5

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

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Durham Phase #4 Expansion

GEOPROBE OW-4

Project No. 98394.802

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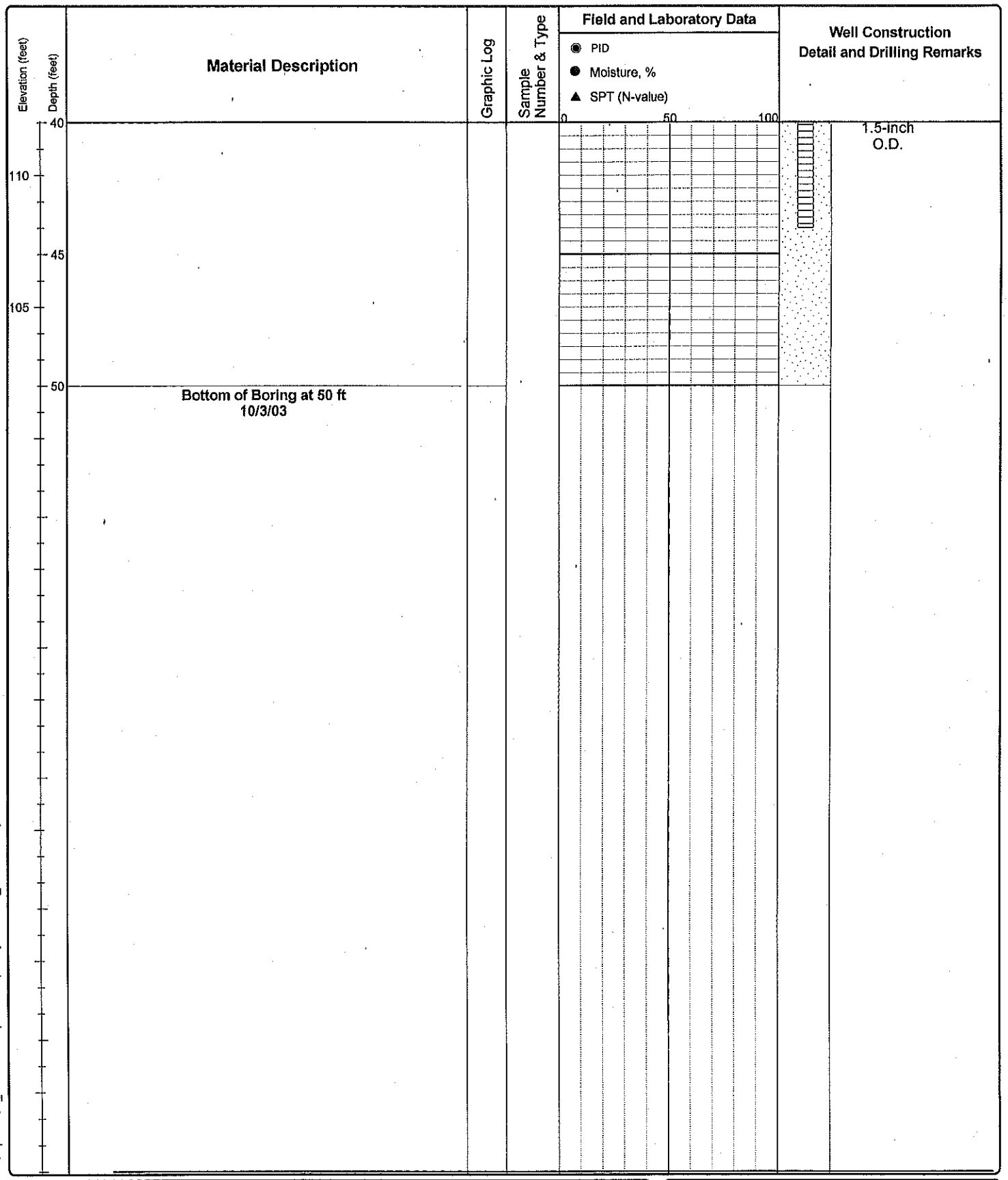
(Sheet 1 of 2)

FIGURE E4



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-4 Printed: 2/12/04

Date Drilling Started: 10/2/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 50.0	Station:	Offset:
Surface Elevation (ft): 152.0	Elevation Datum (ft.)	Coordinates: N 639782.0	E 7619913.5

Durham Phase #4 Expansion

GEOPROBE OW-4

Project No. 98394.802

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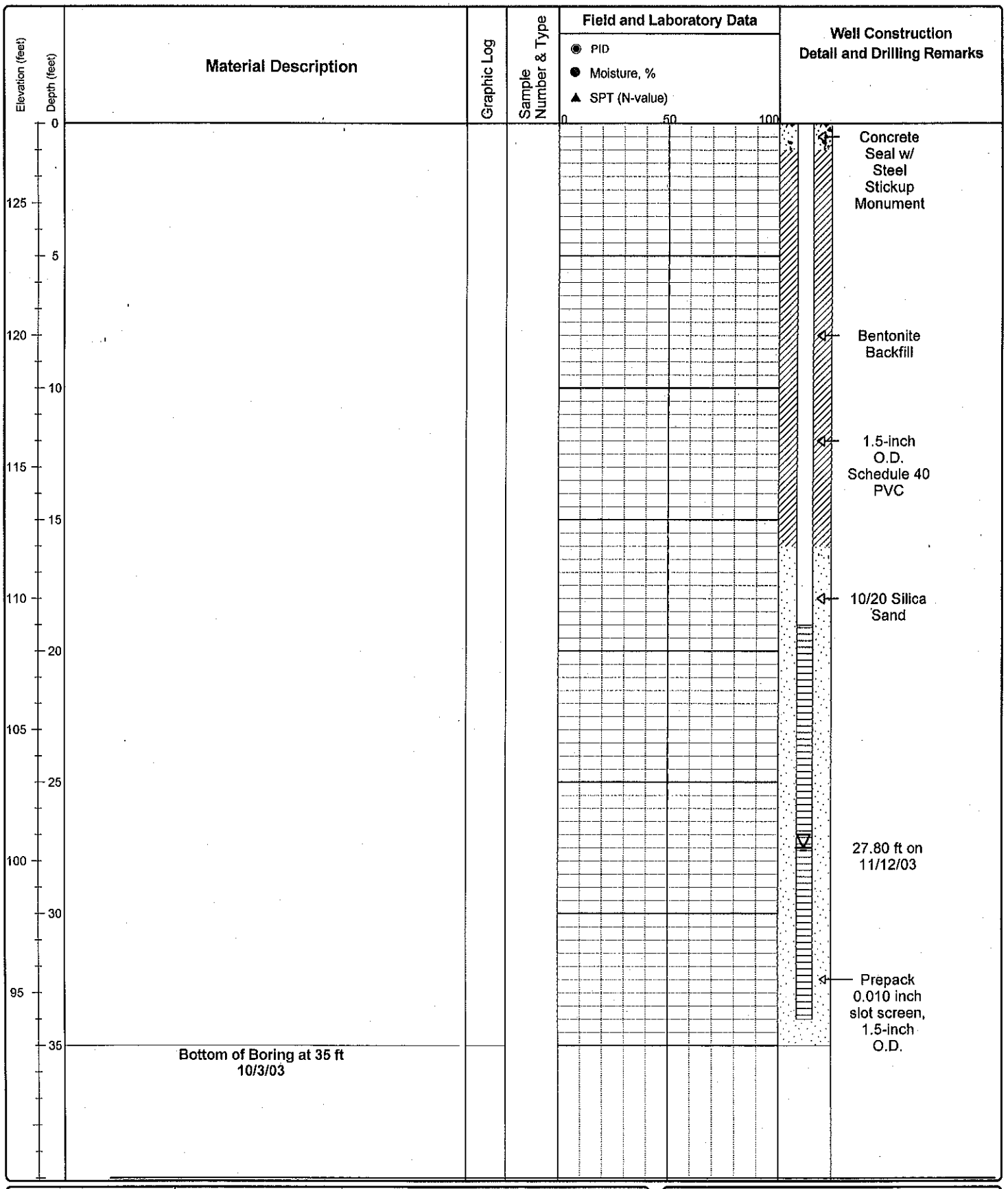
(Sheet 2 of 2)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed R-R

FIGURE E4



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-5 Printed: 2/12/04

Date Drilling Started: 10/3/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 35.0	Station:	Offset:
Surface Elevation (ft): 128.0	Elevation Datum (ft.)	Coordinates: N 639196.6	E 7620591.3

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed

Durham Phase #4 Expansion

GEOPROBE OW-5

Project No. 98394.802

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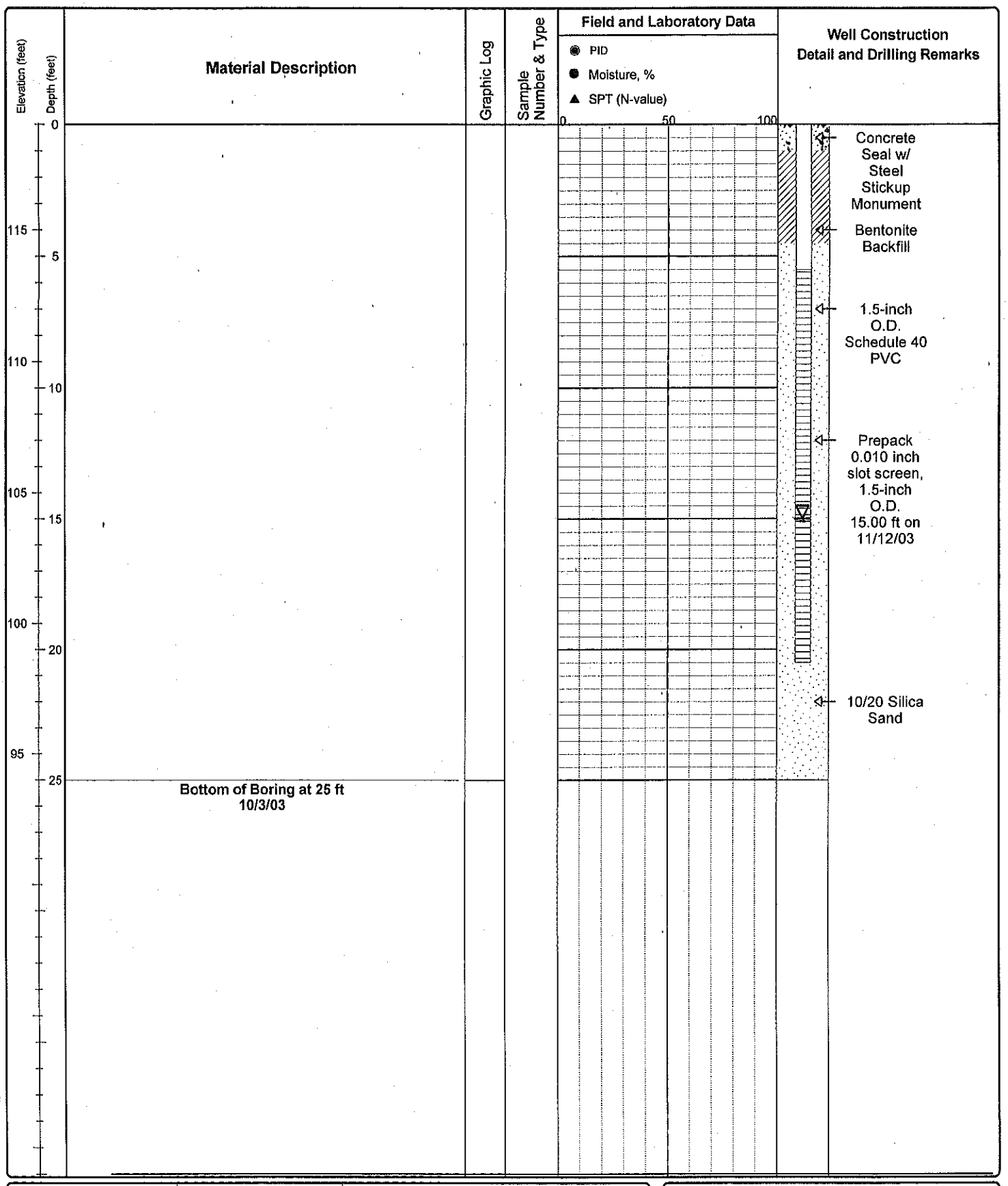
(Sheet 1 of 1)

FIGURE E5



Template: SK_GEOPROBE (ENGLISH) Proj ID: 98394_802.GPJ Key ID: OW-6 Printed: 2/12/04

Date Drilling Started: 10/3/03	Logged By: DRH	Location	
Drilling Method	Start Card Number	Driller: Ryan Galbreth	
Drill Rig Type: GeoProbe 6600	Well ID Number	Wt. Drive Hammer	Borehole Diameter (in.)
Casing Depth (ft)	Total Depth (ft): 25.0	Station:	Offset:
Surface Elevation (ft): 119.0	Elevation Datum (ft.)	Coordinates: N 639433.8	E 7619896.9

Durham Phase #4 Expansion

GEOPROBE OW-6

Project No. 98394.802

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(Sheet 1 of 1)

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

Reviewed R. H.

FIGURE E6

Appendix E.4
1998 Durham Advanced Wastewater Treatment Plant Expansion Phases 3, 4, and 5 Pre-Design

Site Exploration Plan

Durham AWWTP

Note: Base map prepared from a Durham Facility plan provided by HDR.

Legend:

- DM-5 (36) — Existing 1972 Dames and Moore Boring Location and Designation; Depth of Boring in Feet; (DM-1 is Northeast of DM-2 and is Off of this Figure)
- B-17 (22) — Existing Boring Location and Designation; Depth of Boring in Feet
- P-1 (100) — Existing Cone Penetration Test Location; Depth of Cone Penetration in feet
- BH-6 — Hart Crowser Boring Location and Designation
- PH-6 — Hart Crowser Cone Penetration Test Location and Designaiton
- Proposed Structure for Phase 3-4
- Proposed Structure for Phase 5
- Proposed Structure for Phase 6
- Future Roads
- A — A′ Horizontal Cross Section Location and Designation; (Other Sections are not shown)

0 100 200 400

Approximate Scale in Feet

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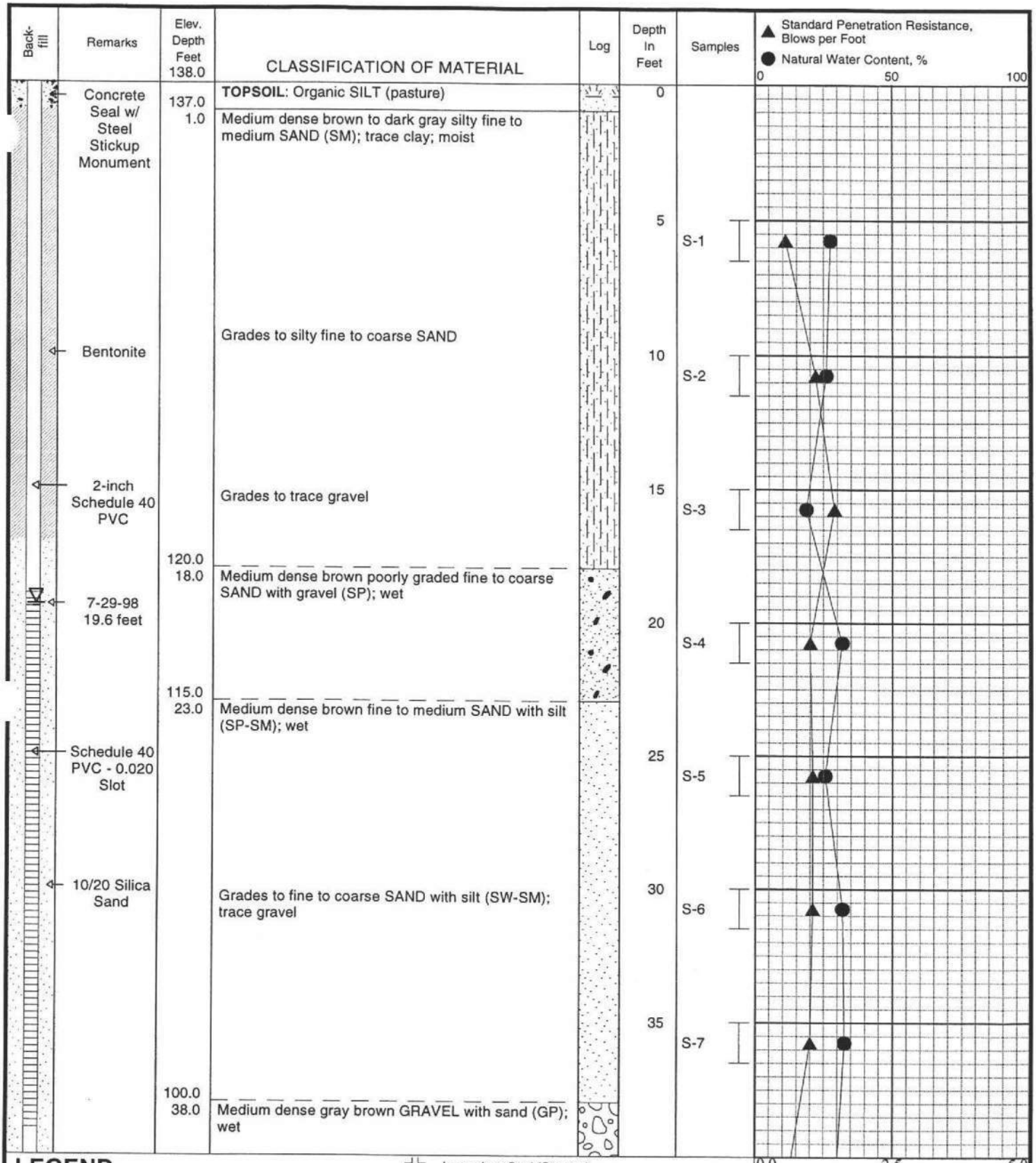
J-5739 7/98

Figure 2



LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ☒ = Grab Sample: Drill Cuttings
- ◘ = CBR Test Sample
- ▽ = Ground Water Level

Impervious Seal (Cement)
Instrumentation Casing
Grout
Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-1

Durham AWWTP
Durham, Oregon

SQUIER ASSOCIATES
AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B1

RINGS.GDT Proj. No.98344 Printed: 9/17/98
Templates: DUF

Back-fill	Remarks	Elev. Depth Feet 138.0	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
		97.0				
		41.0	Stiff gray green CLAY with silt (CH); medium plasticity; moist			S-8
	← Bentonite Backfill		Grades to very stiff CLAY with silt (CH); high plasticity		45	S-9
			Grades to trace fine sand		50	S-10
			Grades to very fine sandy SILT (ML); some light brown mottling; faint organic odor		55	S-11
		81.2				
		56.8	Grades to dark gray CLAY with sand (CL); wet			
		81.2				
		56.8				
		78.0				
		60.0	Dense gray silty SAND (SM); occasional black wood fiber and charcoal; moist		60	S-12
		75.0				
		63.0	Hard dark gray SILT with clay and fine sand (ML); medium plasticity; micaceous; moist		65	S-13
			Grades to gray green SILT (ML); trace clay and fine sand; low plasticity			
	← Bentonite Backfill				70	S-14
						S-15
		65.0				
		73.0	Blue gray to green clayey SILT (MH); trace fine sand; medium plasticity; micaceous; moist		75	S-16
		60.0				
		78.0	Medium dense dark green gray silty fine SAND (SM); trace clay; micaceous; moist			

Standard Penetration Resistance, Blows per Foot

Natural Water Content, %

0 50 100

0.0 2.5 5.0

Shear Strength, T.S.F. (approx.)

Torvane

Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
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- ■ = CBR Test Sample
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Impervious Seal (Cement)
Instrumentation Casing
Grout
Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

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BORING BH-1

Durham AWWTP
Durham, Oregon

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AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B1

JRINGS.GDT. Proj. No.98344 Printed: 9/17/98
Templates: DUI

Back-fill	Remarks	Elev. Depth Feet 138.0	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
			Grades to blue gray to green silty SAND with clay (SM); low plasticity; occasional organics			S-17
					85	
		51.5				S-18
		86.5	Bottom of Boring at 86.5 feet 5/13/98			

Standard Penetration Resistance, Blows per Foot

Natural Water Content, %

0 50 100

0.0 2.5 5.0

Shear Strength, T.S.F. (approx.)

Torvane

Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
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ATTERBERG LIMITS
Liquid Limit
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Plastic Limit

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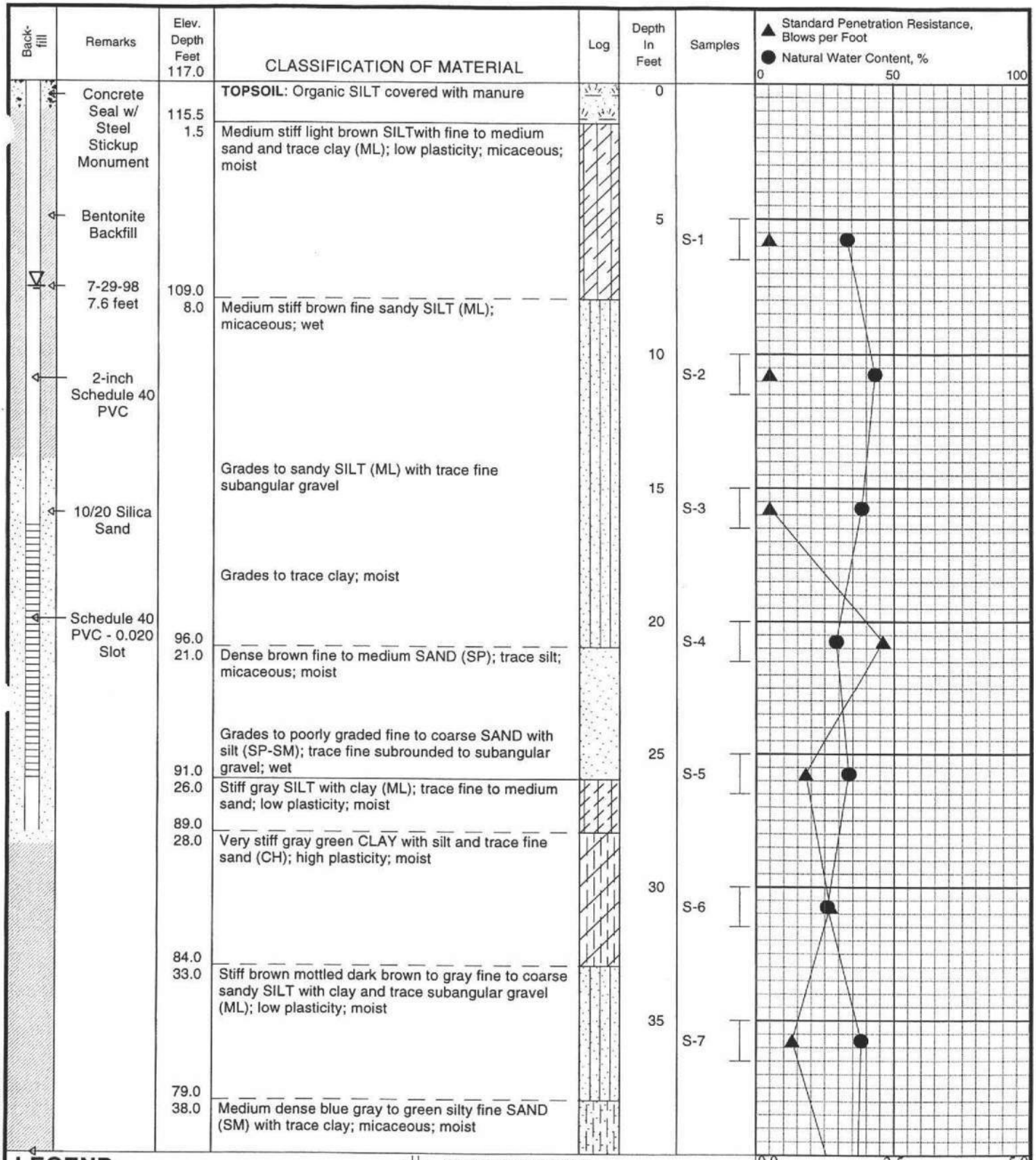
BORING BH-1

Durham AWWTP
Durham, Oregon

SQUIER ASSOCIATES
AUGUST 1998 98344

FIGURE B1



LEGEND

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- * = Sample Not Recovered
- ☒ = Grab Sample: Drill Cuttings
- ☐ = CBR Test Sample
- ▽ = Ground Water Level

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Instrumentation Casing
Grout
Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-3

Durham AWWTP
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RINGS.GDT. Proj. No 98344 Printed: 9/17/98
Templates: DJR

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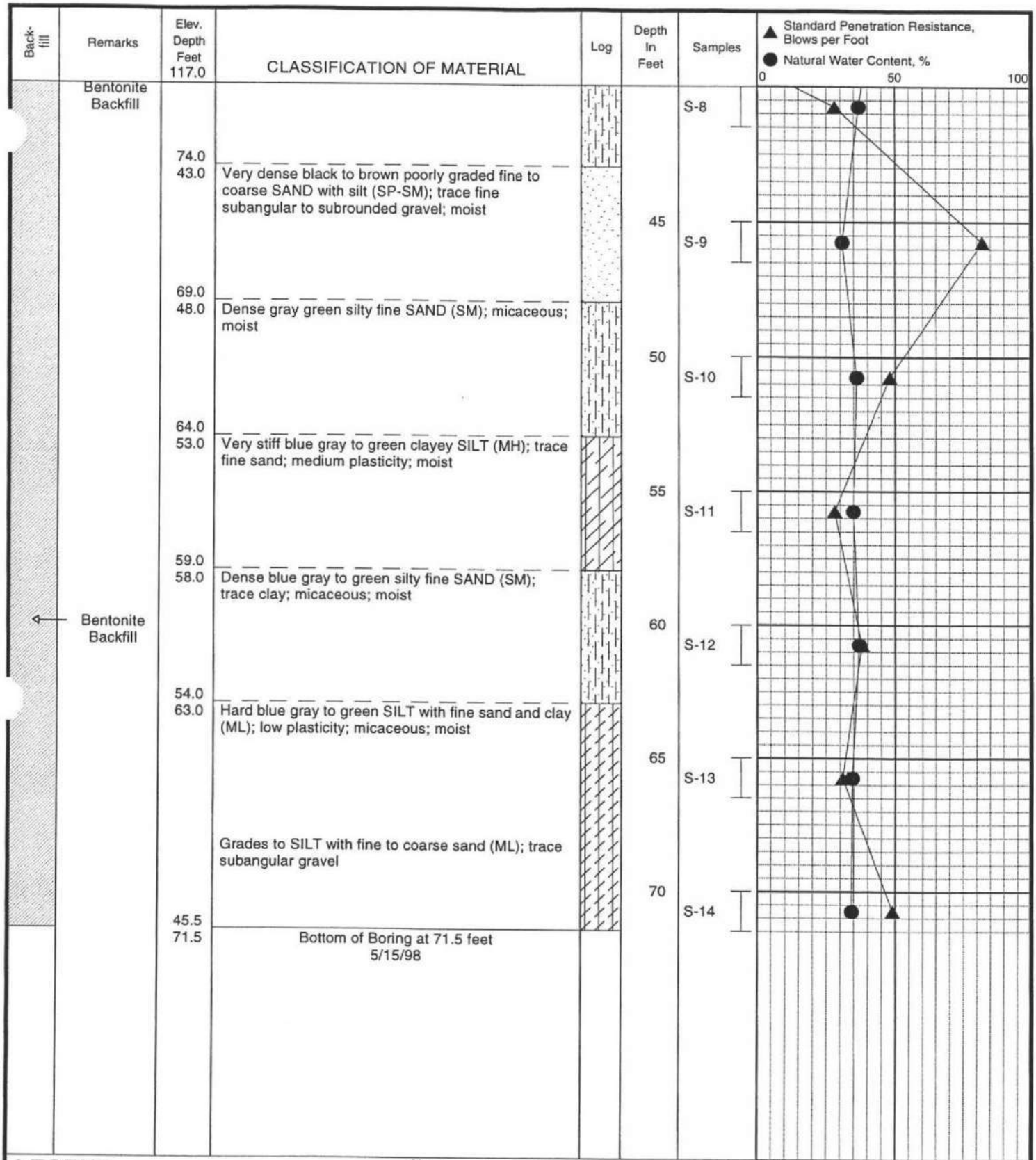
FIGURE B3



LEGEND

- = 2.0" O.D. Split Spoon Sample
- = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- = Grab Sample: Drill Cuttings
- = CBR Test Sample
- = Ground Water Level

Impervious Seal (Cement)
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ATTERBERG LIMITS
Liquid Limit
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Plastic Limit

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BORING BH-3

Durham AWWTP
Durham, Oregon

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AUGUST 1998 98344

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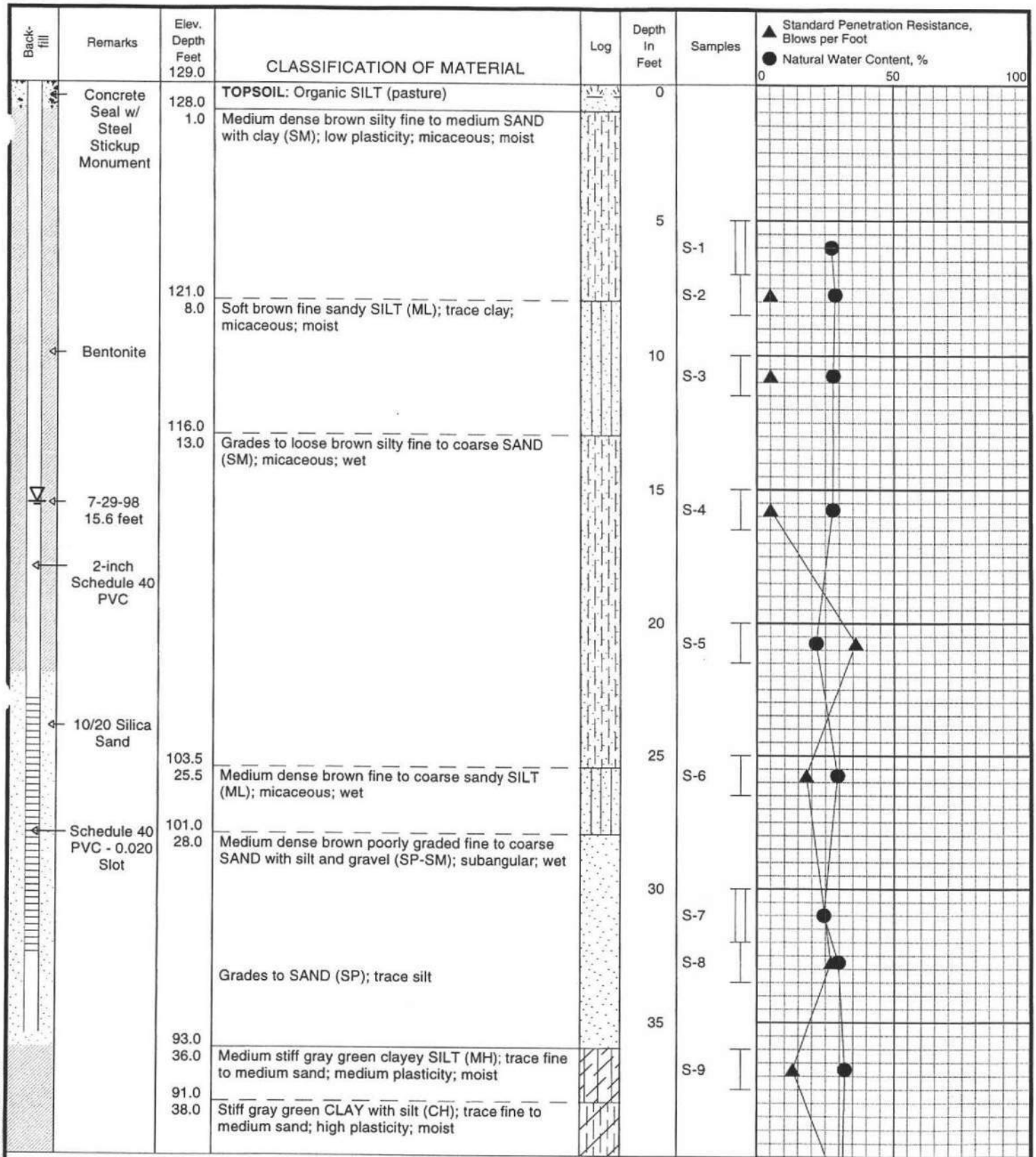
FIGURE B3

'RINGS.GDT Proj. No 98344 Printed: 9/17/98

Templates: DUF



LEGEND

- = 2.0" O.D. Split Spoon Sample
- = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- = Grab Sample: Drill Cuttings
- = CBR Test Sample
- = Ground Water Level

Impervious Seal (Cement)
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Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-4

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Durham, Oregon

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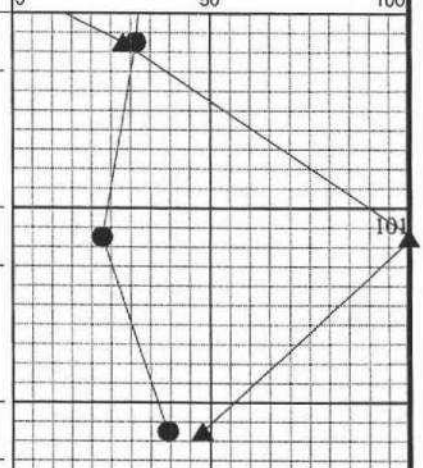
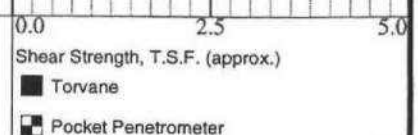
FIGURE B4

RING5.GDT Proj. No 98344 Printed: 9/17/98
Templates: DJR

Back-fill	Remarks	Elev. Depth Feet 129.0	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
			Stiff CLAY with silt (CH)			S-10
←	Bentonite Backfill	86.0 43.0	Very dense brown mottled dark brown to orange silty fine to coarse SAND with clay (SM); low plasticity; moist		45	S-11
			Grades to dense		50	S-12
		77.5 51.5	Bottom of Boring at 51.5 feet 5/18/98			





LEGEND

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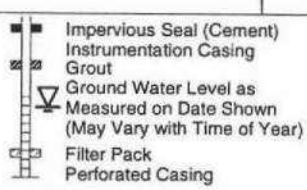
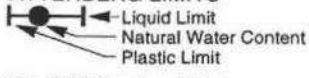
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Grab Sample: Drill Cuttings
- □ = CBR Test Sample
- ▽ = Ground Water Level





NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-4

Durham AWWTP
Durham, Oregon

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AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B4

RING5.GDT. Proj. No. 98344 Printed: 9/17/98

Templates: DUR

Back-fill	Remarks	Elev. Depth Feet 158.0	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
		157.0	**TOPSOIL**: Organic SILT (pasture)		0	
		1.0	Loose brown silty fine to coarse SAND (SM); trace clay; micaceous; moist			
					5	S-1
			Grades to medium dense			
					10	S-2
						S-3
			Grades to fine SAND with silt (SM)		15	S-4
		140.0				
		18.0	Medium dense brown to gray poorly graded fine to coarse SAND (SP); trace silt; moist		20	S-5
	← Bentonite Backfill				25	S-6
					30	S-7
			Grades to well graded SAND with silt (SW-SM); trace gravel; wet		35	S-8
			Grades to poorly graded coarse SAND (SP)			

▲ Standard Penetration Resistance, Blows per Foot
● Natural Water Content, %
0 50 100

0.0 2.5 5.0
Shear Strength, T.S.F. (approx.)
■ Torvane
▪ Pocket Penetrometer

LEGEND

I = 2.0" O.D. Split Spoon Sample
II = 3.0" O.D. Thin-Walled Sample
* = Sample Not Recovered
⊠ = Grab Sample: Drill Cuttings
□ = CBR Test Sample
▽ = Ground Water Level

Impervious Seal (Cement)
Instrumentation Casing
Grout
▽ Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-8

Durham AWWTP
Durham, Oregon

SQUIER ASSOCIATES
AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B7

IING5.GDT Proj. No. 98344 Printed: 9/17/98
Templates: DUPR

Back-fill	Remarks	Elev. Depth Feet	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples
		158.0				
		117.5				
		40.5	Medium dense brown silty fine to coarse SAND (SM); micaceous; moist			S-9
					45	S-10
		110.0				
		48.0	Very stiff gray brown silty CLAY (CH); trace fine to medium sand; high plasticity; moist			
					50	S-11
		105.0				
		53.0	Stiff gray brown clayey SILT with fine to coarse sand (MH); medium plasticity; micaceous; moist			
					55	S-12
			Grades to brown fine sandy SILT (ML)			S-13
			Grades to gray brown and orange; mottled		60	S-14
	← Bentonite Backfill				65	S-15
		90.0				
		68.0	Medium dense green brown to gray silty fine to medium SAND with clay (SM); low plasticity; micaceous; occasional organics; moist		70	S-16
			Grades to dense gray brown and orange silty fine SAND with clay (SM); low plasticity; micaceous; morttled; moist		75	S-17
		80.0				
		78.0	Very stiff blue gray to green clayey SILT (MH); trace fine sand; medium plasticity; micaceous; moist			

Standard Penetration Resistance, Blows per Foot
Natural Water Content, %
0 50 100

0.0 2.5 5.0
Shear Strength, T.S.F. (approx.)
Torvane
Pocket Penetrometer

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Grab Sample: Drill Cuttings
- □ = CBR Test Sample
- ▽ = Ground Water Level

Impervious Seal (Cement)
Instrumentation Casing
Grout
Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-8

Durham AWWTP
Durham, Oregon

SQUIER ASSOCIATES
AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B7

ING5.GDT Proj. No.98344 Printed: 9/17/98
Templates: DUPH

Back-fill	Remarks	Elev. Depth Feet 158.0	CLASSIFICATION OF MATERIAL	Log	Depth In Feet	Samples	Standard Penetration Resistance, Blows per Foot / Natural Water Content, % (0 – 50 – 100)
		76.5				S-18	
		81.5	Bottom of Boring at 81.5 feet 5/19/98				

LEGEND

- I = 2.0" O.D. Split Spoon Sample
- II = 3.0" O.D. Thin-Walled Sample
- * = Sample Not Recovered
- ⊠ = Grab Sample: Drill Cuttings
- ◘ = CBR Test Sample
- ▽ = Ground Water Level

Impervious Seal (Cement)
Instrumentation Casing
Grout
Ground Water Level as Measured on Date Shown (May Vary with Time of Year)
Filter Pack
Perforated Casing

ATTERBERG LIMITS
Liquid Limit
Natural Water Content
Plastic Limit

Shear Strength, T.S.F. (approx.) (0.0 – 2.5 – 5.0)
■ Torvane
Pocket Penetrometer

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only and may indicate gradual transition

BORING BH-8

Durham AWWTP
Durham, Oregon

SQUIER ASSOCIATES
AUGUST 1998 98344

HARTCROWSER

Reviewed MFS

FIGURE B7

3INGS.GDT. Proj. No 98344 Printed: 9/17/98
Templates: DI/RI

TABLE D1. SUMMARY OF GEOTECHNICAL LABORATORY TEST DATA

Boring	Depth (feet)	Sample Number	Sample Type	Visual Classification	Water Content %	In-Situ Wet Density (pcf)	In-Situ Dry Density (pcf)	Direct Shear		Consolidation			Unconfined Compressive Strength (psf)	Plastic Limit	Liquid Limit	Plasticity Index	Grain Size Distribution			USCS	Soil Classification
								c' (psi)	phi (degrees)	Cr	Cc	Pc' (psf)					% Gravel	% Sand	% Fines		
BH-1	5	S-1	SPT	x	27.5															SM	Silty SAND
BH-1	10	S-2	SPT	x	26.0															SM	Silty fine to coarse SAND
BH-1	15	S-3	SPT	x	18.6												4	78.3	17.7	SM	Silty SAND
BH-1	20	S-4	SPT	x	31.8															SP	Poorly graded fine to coarse SAND with gravel
BH-1	25	S-5	SPT	x	25.6															SP-SM	Poorly graded SAND with silt
BH-1	30	S-6	SPT	x	31.9												5.4	85.6	9	SW-SM	Well graded fine to coarse SAND with silt
BH-1	35	S-7	SPT	x	32.6															SW-SM	Well graded SAND with silt
BH-1	40	S-8	SPT	x	29.7															GP	CLAY with silt
BH-1	45	S-9	SPT	x	32.6									22.8	74.5	51.7				CH	CLAY with silt
BH-1	50	S-10	SPT	x	26.7															CH	CLAY with silt , trace fine sand
BH-1	55	S-11	Shelby	x	23.2	130.2	105.7	725	32.0				4000							ML	Very fine sandy SILT
BH-1	60	S-12	SPT	x	33.9															SM	Silty SAND
BH-1	65	S-13	SPT	x	38.9															ML	SILT with clay and fine sand
BH-1	70	S-14	Shelby	x	28.7	122.9	95.5													ML	SILT, trace clay and fine sand
BH-1	71	S-15	SPT	x	31.1															ML	SILT
BH-1	75	S-16	SPT	x	40.4															MH	Clayey SILT
BH-1	80	S-17	SPT	x	39.3															SM	Silty SAND with clay
BH-1	85	S-18	SPT	x	39.9															SM	Silty SAND with clay
BH-2	5	S-1	SPT	x	21.4															SM	Silty fine to coarse SAND with clay
BH-2	10	S-2	Shelby	x	19.4	130	108.9													SM	Silty SAND, trace gravel
BH-2	11.7	S-3	SPT	x	23.9															SM	Silty SAND
BH-2	15	S-4	SPT	x	25.4															SM	Silty SAND
BH-2	20	S-5	Shelby	x	29.4	119.3	92.2	450	33.0											MH	Clayey SILT with fine to coarse sand
BH-2	22	S-6	SPT	x	26.6															SM	Silty fine to coarse SAND with clay
BH-2	25	S-7	SPT	x	29.5												1.6	51.2	47.2	SM	Silty fine to medium SAND
BH-2	30	S-8	SPT	x	29.2															ML	SILT with clay
BH-2	35	S-9	SPT	x	37.8									26	36.5	10.5				ML	SILT with clay, trace fine sand
BH-2	40	S-10	SPT	x	25.9															CL	Silty CLAY, trace fine sand
BH-2	45	S-11	SPT	x	34.6															CL	Silty CLAY, trace fine sand
BH-2	50	S-12	SPT	x	26.3															MH	Clayey SILT, with fine to coarse sand
BH-2	55	S-13	SPT	x	44.0															SM	Silty fine to coarse SAND
BH-2	60	S-14	SPT	x	31.0															MH	Clayey SILT with fine sand
BH-2	65	S-15	SPT	x	32.7															ML	Fine sandy SILT with clay
BH-3	5	S-1	SPT	x	33.3															ML	SILT with fine to medium sand
BH-3	10	S-2	SPT	x	43.2															ML	Fine sandy SILT
BH-3	15	S-3	SPT	x	38.3												1.5	47.5	51	ML	Fine sandy SILT
BH-3	20.0	S-4	SPT	x	29.1															SP	Poorly graded fine to medium SAND, trace silt
BH-3	25	S-5	SPT	x	33.6															ML	SILT with clay
BH-3	30.0	S-6	SPT	x	25.9															CH	CLAY with silt, trace fine sand
BH-3	35.0	S-7	SPT	x	38.0															ML	Fine to coarse sandy SILT with clay
BH-3	40	S-8	SPT	x	36.8									29.1	35.1	6.1				SM	Silty fine SAND
BH-3	45.0	S-9	SPT	x	30.8															SP-SM	Poorly graded fine to coarse SAND with silt
BH-3	50.0	S-10	SPT	x	36.0															SM	Silty fine SAND
BH-3	55	S-11	SPT	x	34.8									30.7	55.6	24.9				MH	Clayey SILT, trace fine sand
BH-3	60.0	S-12	SPT	x	37.0															SM	Silty fine SAND
BH-3	65.0	S-13	SPT	x	34.5															ML	SILT with sand and clay
BH-3	70.0	S-14	SPT	x	34.1															ML	SILT with fine to coarse sand
BH-4	5.0	S-1	Shelby	x	27.4	124.8	98.0													SM	Silty fine to medium SAND with clay
BH-4	7.0	S-2	SPT	x	28.7															SM	Silty SAND with clay
BH-4	10	S-3	SPT	x	27.9															ML	Fine sandy SILT
BH-4	15.0	S-4	SPT	x	27.7												0.1	79.5	20.4	SM	Silty fine SAND
BH-4	20.0	S-5	SPT	x	21.6															SM	Silty fine SAND
BH-4	25.0	S-6	SPT	x	29.4															ML	Fine to coarse sandy SILT
BH-4	30.0	S-7	Shelby	x	24.4	113.5	91.2													SP-SM	Poorly graded fine to coarse SAND
BH-4	32.0	S-8	SPT	x	29.7															SP-SM	Poorly graded fine to coarse SAND
BH-4	36.0	S-9	SPT	x	32.0															MH	Clayey SILT, trace fine to medium sand
BH-4	40.0	S-10	SPT	x	31.3									49.2	70.7	21.5				CH	CLAY with silt

TABLE D1. SUMMARY OF GEOTECHNICAL LABORATORY TEST DATA

Boring	Depth (feet)	Sample Number	Sample Type	Visual Classification	Water Content %	In-Situ Wet Density (pcf)	In-Situ Dry Density (pcf)	Direct Shear		Consolidation			Unconfined Compressive Strength (psf)	Plastic Limit	Liquid Limit	Plasticity Index	Grain Size Distribution			USCS	Soil Classification
								c' (psi)	phi (degrees)	Cr	Cc	Pc' (psf)					% Gravel	% Sand	% Fines		
BH-4	45.0	S-11	SPT	x	22.7															SM	Silty fine to coarse SAND with clay
BH-4	50	S-12	SPT	x	39.3															SM	Silty fine to coarse SAND with clay
BH-6	5	S-1	SPT	x	33.2															SM	Silty fine to medium SAND
BH-6	10	S-2	SPT	x	27.7															SP-SM	Poorly graded fine to coarse SAND with silt
BH-6	11.5	S-3	Shelby	x	25.9	124.9	99.2													SP-SM	Poorly graded SAND with silt
BH-6	15	S-4	SPT	x	26.6															SP-SM	Poorly graded SAND with silt
BH-6	21	S-5	SPT	x	36.8															ML	SILT with clay and sand
BH-6	23	S-6	Shelby	x	43.7	113.2	78.8			0.024	0.105	6000		30.7	78	47.3				CH	CLAY with silt
BH-6	25.5	S-7	SPT	x	34.8															CH	CLAY with silt
BH-6	30	S-8	SPT	x	48.3															CH	CLAY with silt
BH-6	35	S-9	SPT	x	34.4															ML	Clayey SILT with fine sand
BH-6	40	S-10	SPT	x	33.4															ML	Clayey fine to coarse sandy SILT
BH-7	5	S-1	SPT	x	33.0															ML	SILT with clay and fine to medium sand
BH-7	10	S-2	Shelby	x	26.2															SM	Silty fine to medium SAND
BH-7	12	S-3	SPT	x	26.6															SM,	Silty fine to medium SAND
BH-7	15	S-4	SPT	x	27.4															ML	SILT with fine sand
BH-7	20	S-5	Shelby	x	31.9	115.7	87.7													SP	Poorly graded fine to coarse SAND with gravel
BH-7	21.5	S-6	SPT	x	*															SP	Poorly graded fine to coarse SAND with gravel
BH-7	25	S-7	SPT	x	*															SP	Poorly graded fine to coarse SAND with gravel
BH-7	30	S-8	SPT	x	35.6															CH	CLAY with silt
BH-7	35	S-9	SPT	x	39.2															ML	Clayey fine to medium sandy SILT
BH-7	40	S-10	SPT	x	37.1															ML	Clayey fine to coarse sandy SILT
BH-8	5	S-1	SPT	x	31.1															SM	Silty fine to coarse SAND
BH-8	10	S-2	Shelby	x	24.8	122.6	98.2													SM	Silty fine to coarse SAND
BH-8	12	S-3	SPT	x	23.6															SP-SM	Poorly graded SAND with silt
BH-8	15	S-4	SPT	x	22.4															SP-SM	Poorly graded SAND with silt
BH-8	20	S-5	SPT	x	24.7															SP	Fine to coarse SAND, trace silt
BH-8	25	S-6	SPT	x	19.5															SP	Fine to coarse SAND
BH-8	30	S-7	SPT	x	13.0															SP	Fine to coarse SAND
BH-8	35	S-8	SPT	x	23.8												2.7	89.5	7.8	SW-SM	Well graded fine to coarse SAND with silt
BH-8	40	S-9	SPT	x	28.6															SM	Silty fine to coarse SAND
BH-8	45	S-10	SPT	x	30.2															SM	Silty SAND
BH-8	50	S-11	SPT	x	27.9															CH	Silty CLAY
BH-8	55	S-12	Shelby	x	25.1	127.3	101.8													MH	Clayey SILT with fine to coarse sand
BH-8	57	S-13	SPT	x	28.2												0.1	35.5	64.4	ML	Fine sandy SILT
BH-8	60	S-14	SPT	x	37.4															ML	Sandy SILT
BH-8	65	S-15	SPT	x	34.2															ML	Sandy SILT
BH-8	70	S-16	SPT	x	38.7															SM	Silty fine to medium SAND with clay
BH-8	75	S-17	SPT	x	35.3															SM	Silty fine SAND with clay
BH-8	80	S-18	SPT	x	36.5															MH	Clayey SILT
DM-12**	15.5	S-4	Shelby	x	12.5	118.7	105.5			0.008	0.03	1840								SP-SM	Poorly graded SAND with silt

* Moisture content judged to be unreliable due to presence of gravel.
** Test results obtained from Dames & Moore Report, 1972.

MC

Moisture Content Determination

Job No 98344

Tested By/Date: **AR 6/3/98**
Calc. By/Date **AR 6/5/98**
Check. By/Date MFS 9/9/98

Specimen Data:

Boring No.	BH-1	BH-1	BH-1	BH-1	BH-1	BH-1	BH-1
Sample No.	S-1	S-2	S-3	S-4	S-5	S-6	S-7
Depth (ft)	5.0	10.0	15.0	20.0	25.0	30.0	35.0
Tare #	A-10	A-28	D-22	D-37	P-8	D-26	P-25
Wt.Tare + Wet (grams)	320.8	365.1	350.6	397.3	284.9	412.5	290.8
Wt.Tare + Dry (grams)	292.6	328.8	326.3	349.8	245.5	360.0	241.1
Wt.Tare (grams)	190.0	189.1	195.6	200.4	91.5	195.4	88.5
Water Content (%)	**27.5**	**26.0**	**18.6**	**31.8**	**25.6**	**31.9**	**32.6**

Boring No.	BH-1	BH-1	BH-1	BH-1	BH-1	BH-1	BH-1
Sample No.	S-8a	S-9	S-10	S-12	S-13	S-15	S-16
Depth (ft)	40.0	45.0	50.0	60.0	65.0	71.0	75.0
Tare #	A-20	D-15	D-31	D-14	P-23	A-13	X-1
Wt.Tare + Wet (grams)	313.2	359.1	322.5	362.7	195.2	290.5	330.0
Wt.Tare + Dry (grams)	284.8	320.0	296.8	320.4	165.3	266.4	292.7
Wt.Tare (grams)	189.3	200.1	200.6	195.5	88.5	188.9	200.4
Water Content (%)	**29.7**	**32.6**	**26.7**	**33.9**	**38.9**	**31.1**	**40.4**

Boring No.	BH-1	BH-1	BH-2	BH-2	BH-2	BH-2	BH-2
Sample No.	S-17	S-18	S-1	S-3	S-4	S-6	S-7
Depth (ft)	80.0	85.0	5.0	11.7	15.0	22.0	25.0
Tare #	A-18	A-5	D-42	D-1	A-33	D-13	A-40
Wt.Tare + Wet (grams)	310.2	304.7	312.7	366.9	331.8	287.8	326.3
Wt.Tare + Dry (grams)	276.2	272.0	292.0	334.8	303.0	268.4	295.2
Wt.Tare (grams)	189.7	190.1	195.3	200.4	189.5	195.5	189.7
Water Content (%)	**39.3**	**39.9**	**21.4**	**23.9**	**25.4**	**26.6**	**29.5**

MC

Moisture Content Determination

Job No 98344

Tested By/Date: AR 6/3/98
Calc. By/Date AR 6/5/98
Check. By/Date MFS 7/9/98

Specimen Data:

Boring No.	BH-2	BH-2	BH-2	BH-2	BH-2	BH-2	BH-2
Sample No.	S-8	S-9	S-10	S-11	S-12	S-13	S-14
Depth (ft)	30.0	35.0	40.0	45.0	50.0	55.0	60.0
Tare #	A-26	D-29	A-41	D-44	D-18	D-36	A-42
Wt.Tare + Wet (grams)	315.1	302.5	303.5	307.2	308.8	333.2	311.5
Wt.Tare + Dry (grams)	286.7	273.2	280.1	278.5	285.2	292.6	282.8
Wt.Tare (grams)	189.3	195.6	189.7	195.5	195.3	200.4	190.1
Water Content (%)	**29.2**	**37.8**	**25.9**	**34.6**	**26.3**	**44.0**	**31.0**

Boring No.	BH-2	BH-3	BH-3	BH-3	BH-3	BH-3	BH-3
Sample No.	S-15	S-1	S-2	S-3	S-4	S-5	S-6
Depth (ft)	65.0	5.0	10.0	15.0	20.0	25.0	30.0
Tare #	D-23	D-35	D-11	A-12	A-43	A-30	D-18
Wt.Tare + Wet (grams)	327.2	349.0	320.6	298.9	294.7	291.0	299.7
Wt.Tare + Dry (grams)	294.7	311.9	284.4	268.4	271.1	265.4	278.2
Wt.Tare (grams)	195.4	200.6	200.6	188.8	190.1	189.2	195.3
Water Content (%)	**32.7**	**33.3**	**43.2**	**38.3**	**29.1**	**33.6**	**25.9**

Boring No.	BH-3	BH-3	BH-3	BH-3	BH-3	BH-3	BH-3
Sample No.	S-7	S-8	S-9	S-10	S-11	S-12	S-13
Depth (ft)	35.0	40.0	45.0	50.0	55.0	60.0	65.0
Tare #	A-34	A-17	A-21	D-12	D-43	A-46	A-38
Wt.Tare + Wet (grams)	305.2	299.9	309.0	321.4	300.4	300.4	292.2
Wt.Tare + Dry (grams)	273.4	270.2	280.9	289.4	273.3	270.4	265.8
Wt.Tare (grams)	189.7	189.6	189.6	200.5	195.5	189.3	189.3
Water Content (%)	**38.0**	**36.8**	**30.8**	**36.0**	**34.8**	**37.0**	**34.5**

MC

Moisture Content Determination

Job No **98344**

Tested By/Date: **AR 6/3/98**
Calc. By/Date **AR 6/5/98**
Check. By/Date MFS 7/9/98

Specimen Data:

Boring No.	BH-3	BH-3	BH-4	BH-4	BH-4	BH-4	BH-4
Sample No.	S-14	S-5b	S-2	S-3	S-4	S-5	S-6
Depth (ft)	70.0	26.5	7.0	10.0	15.0	20.0	25.0
Tare #	P-21	D-33	A-14	D-2	D-32	A-46	D-38
Wt.Tare + Wet (grams)	192.5	308.3	309.0	350.8	366.1	358.0	368.9
Wt.Tare + Dry (grams)	166.0	282.6	282.3	318.0	329.1	328.0	330.7
Wt.Tare (grams)	88.4	200.7	189.2	200.6	195.6	189.2	200.7
Water Content (%)	**34.1**	**31.4**	**28.7**	**27.9**	**27.7**	**21.6**	**29.4**

Boring No.	BH-4	BH-4	BH-4	BH-4	BH-4	BH-6	BH-6
Sample No.	S-8	S-9	S-10	S-11	S-12	S-1	S-2
Depth (ft)	32.0	36.0	40.0	45.0	50.0	5.0	10.0
Tare #	T-3	D-16	P-6	P-1	D-27	A-9	A-44
Wt.Tare + Wet (grams)	382.2	324.9	200.2	201.5	318.2	293.0	292.7
Wt.Tare + Dry (grams)	325.6	293.5	174.2	181.1	285.0	267.2	270.4
Wt.Tare (grams)	134.9	195.5	91.2	91.4	200.5	189.6	189.9
Water Content (%)	**29.7**	**32.0**	**31.3**	**22.7**	**39.3**	**33.2**	**27.7**

Boring No.	BH-6	BH-6	BH-6	BH-6	BH-6	BH-6	BH-7
Sample No.	S-4	S-5	S-7	S-8	S-9	S-10	S-1
Depth (ft)	15.0	21.0	25.5	30.0	35.0	40.0	5.0
Tare #	D-40	A-39	A-27	A-15	D-9	D-34	D-4
Wt.Tare + Wet (grams)	325.4	310.3	308.3	295.6	325.3	305.2	319.6
Wt.Tare + Dry (grams)	298.1	283.9	277.5	261.0	292.1	279.0	290.1
Wt.Tare (grams)	195.3	189.7	188.9	189.4	195.5	200.6	200.6
Water Content (%)	**26.6**	**28.0**	**34.8**	**48.3**	**34.4**	**33.4**	**33.0**

MC

Moisture Content Determination

Job No 98344

Tested By/Date: **AR 6/3/98**
Calc. By/Date **AR 6/5/98**
Check. By/Date MES 9/9/98

Specimen Data:

Boring No.	BH-7	BH-7	BH-7	BH-7	BH-7	BH-8	BH-8
Sample No.	S-3	S-4	S-8	S-9	S-10	S-1	S-3
Depth (ft)	12.0	15.0	30.0	35.0	40.0	5.0	12.0
Tare #	D-28	A-7	P-26	P-10	P-22	T-4	T-1
Wt.Tare + Wet (grams)	326.0	366.9	191.5	193.2	190.8	269.7	253.4
Wt.Tare + Dry (grams)	298.6	328.8	164.3	164.5	163.1	237.8	230.8
Wt.Tare (grams)	195.5	189.5	88.5	91.3	88.4	135.1	135.1
Water Content (%)	**26.6**	**27.4**	**35.9**	**39.2**	**37.1**	**31.1**	**23.6**

Boring No.	BH-8	BH-8	BH-8	BH-8	BH-8	BH-8	BH-8
Sample No.	S-4	S-5	S-6	S-7	S-8	S-9	S-10
Depth (ft)	15.0	20.0	25.0	30.0	35.0	41.0	45.0
Tare #	A-36	D-7	A-16	D-41	A-11	D-16	A-1
Wt.Tare + Wet (grams)	314.3	335.9	292.9	291.0	355.6	366.8	321.4
Wt.Tare + Dry (grams)	291.5	308.1	276.1	280.0	323.6	329.8	290.7
Wt.Tare (grams)	189.5	195.6	190.0	195.3	189.2	200.6	189.1
Water Content (%)	**22.4**	**24.7**	**19.5**	**13.0**	**23.8**	**28.6**	**30.2**

Boring No.	BH-8	BH-8	BH-8	BH-8	BH-8	BH-8	BH-8
Sample No.	S-11	S-13	S-14	S-15	S-16	S-17	S-18
Depth (ft)	50.0	57.0	60.0	65.0	70.0	75.0	80.0
Tare #	D-8	A-22	D-6	T-3	D-43	A-20	A-24
Wt.Tare + Wet (grams)	310.9	309.5	299.2	248.4	322.3	313.4	303.3
Wt.Tare + Dry (grams)	285.7	283.2	271.0	219.5	285.3	281.0	272.9
Wt.Tare (grams)	195.4	190.0	195.5	135.0	189.7	189.3	189.5
Water Content (%)	**27.9**	**28.2**	**37.4**	**34.2**	**38.7**	**35.3**	**36.5**

MA

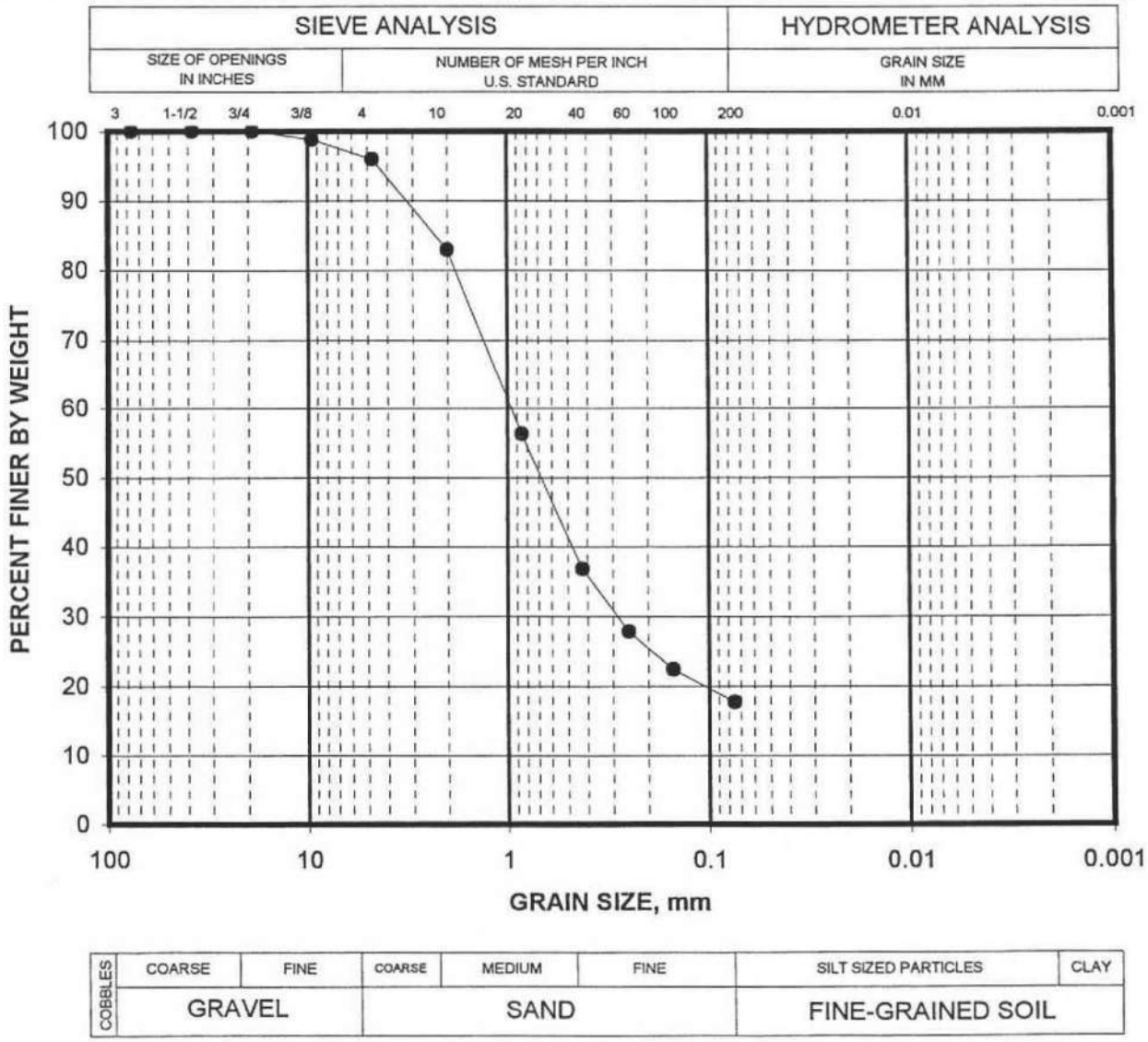
Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-1	Calc. By/Date	AR 6/23/98
Sample	S-3	Check. By/Date	MFS 9/9/98
Depth, ft.	15		

CLASSIFICATION:

Brown silty fine to coarse SAND; trace gravel

USCS Classification: SM



SQUIER ASSOCIATES	PROJECT: Durham AWWTP	MA

HARTCROWSER

FIGURE D5

MA

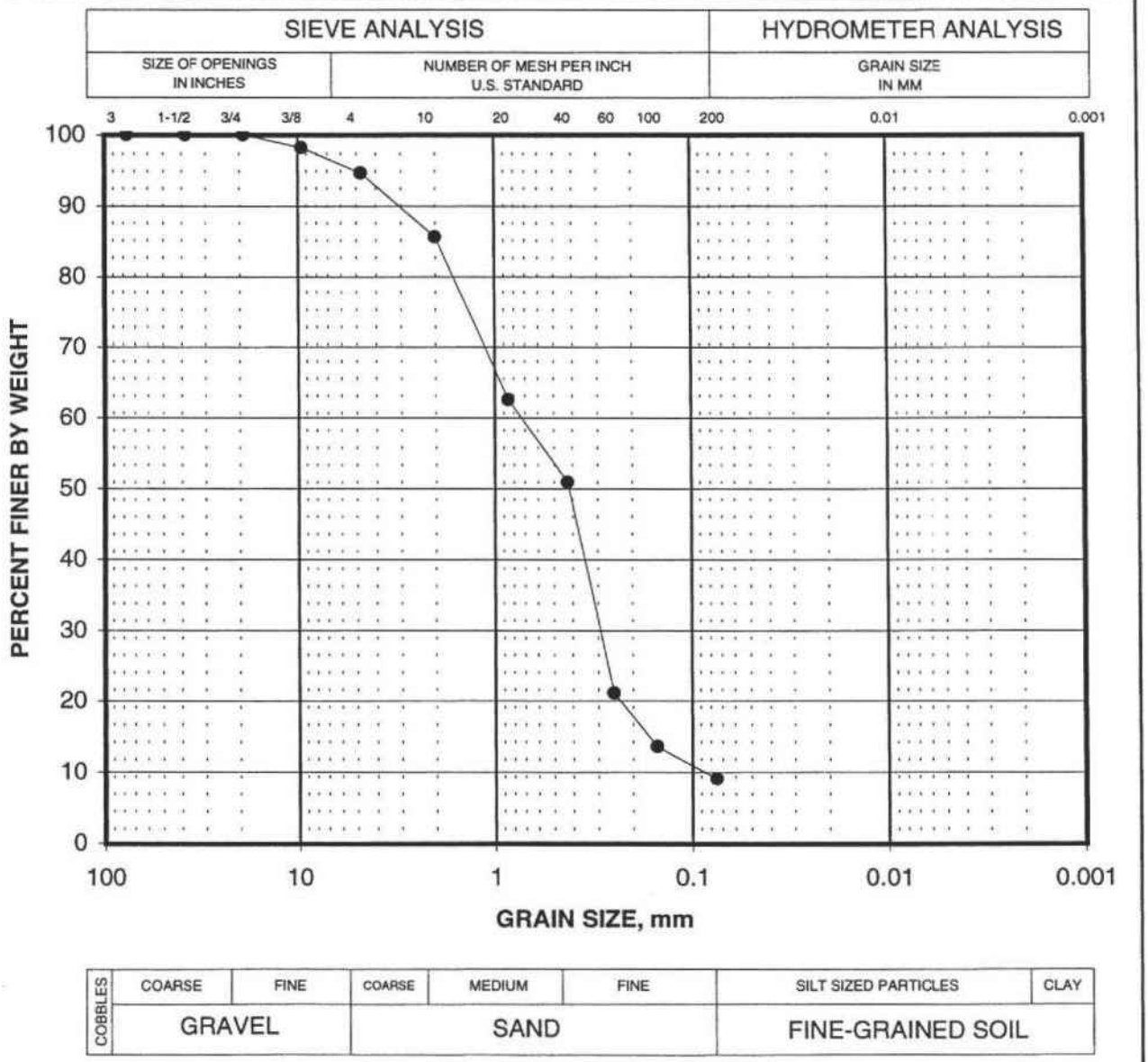
Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-1	Calc. By/Date	AR 6/23/98
Sample	S-6	Check. By/Date	MFS 9/9/98
Depth, ft.	30		

CLASSIFICATION:

Brown well graded fine to coarse SAND with silt; trace gravel

USCS Classification: SW-SM



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D6

MA

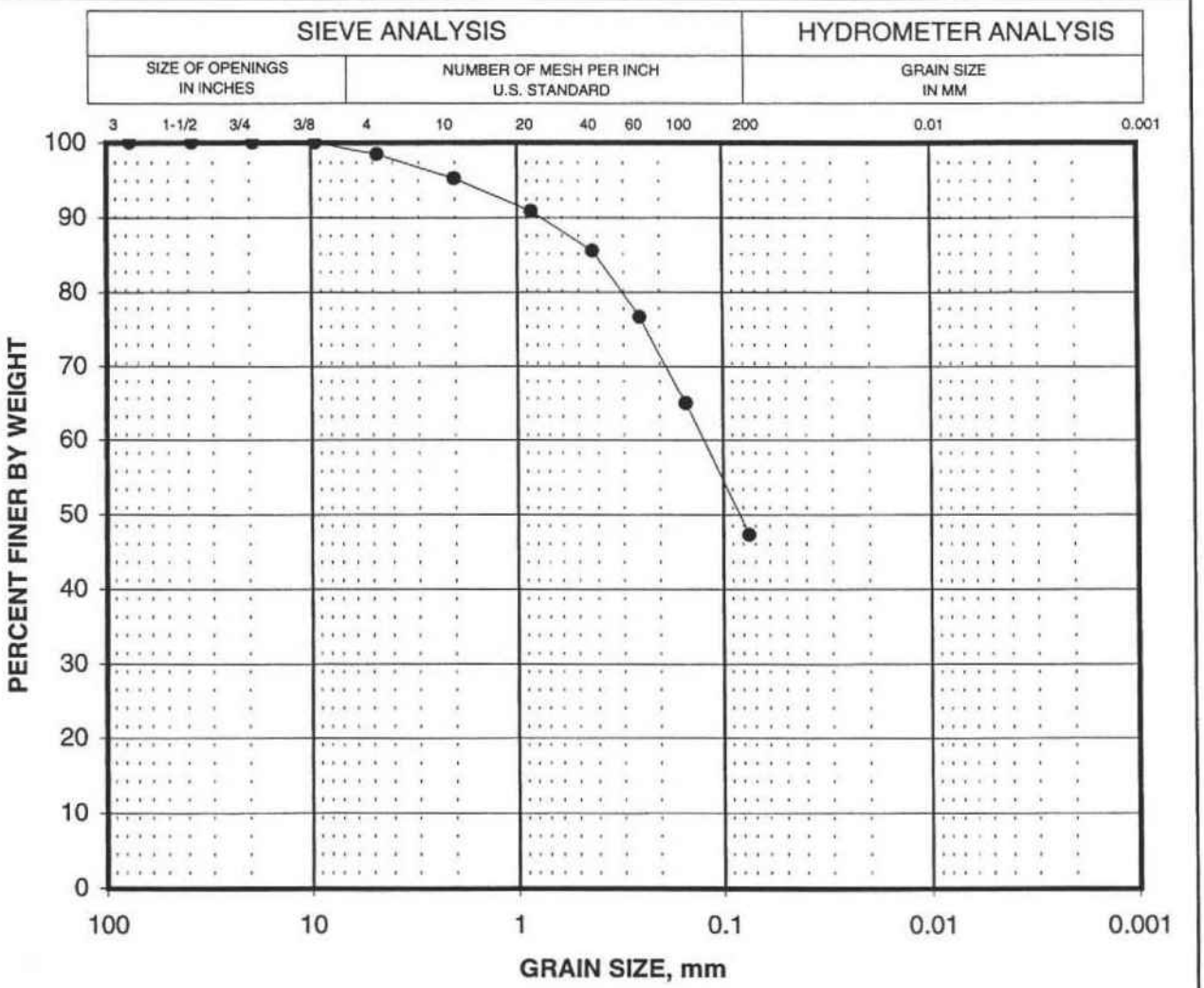
Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-2	Calc. By/Date	AR 6/23/98
Sample	S-7	Check. By/Date	MFS 9/9/98
Depth, ft.	25		

CLASSIFICATION:

Brown silty fine to medium SAND; trace gravel

USCS Classification: SM



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D7

MA

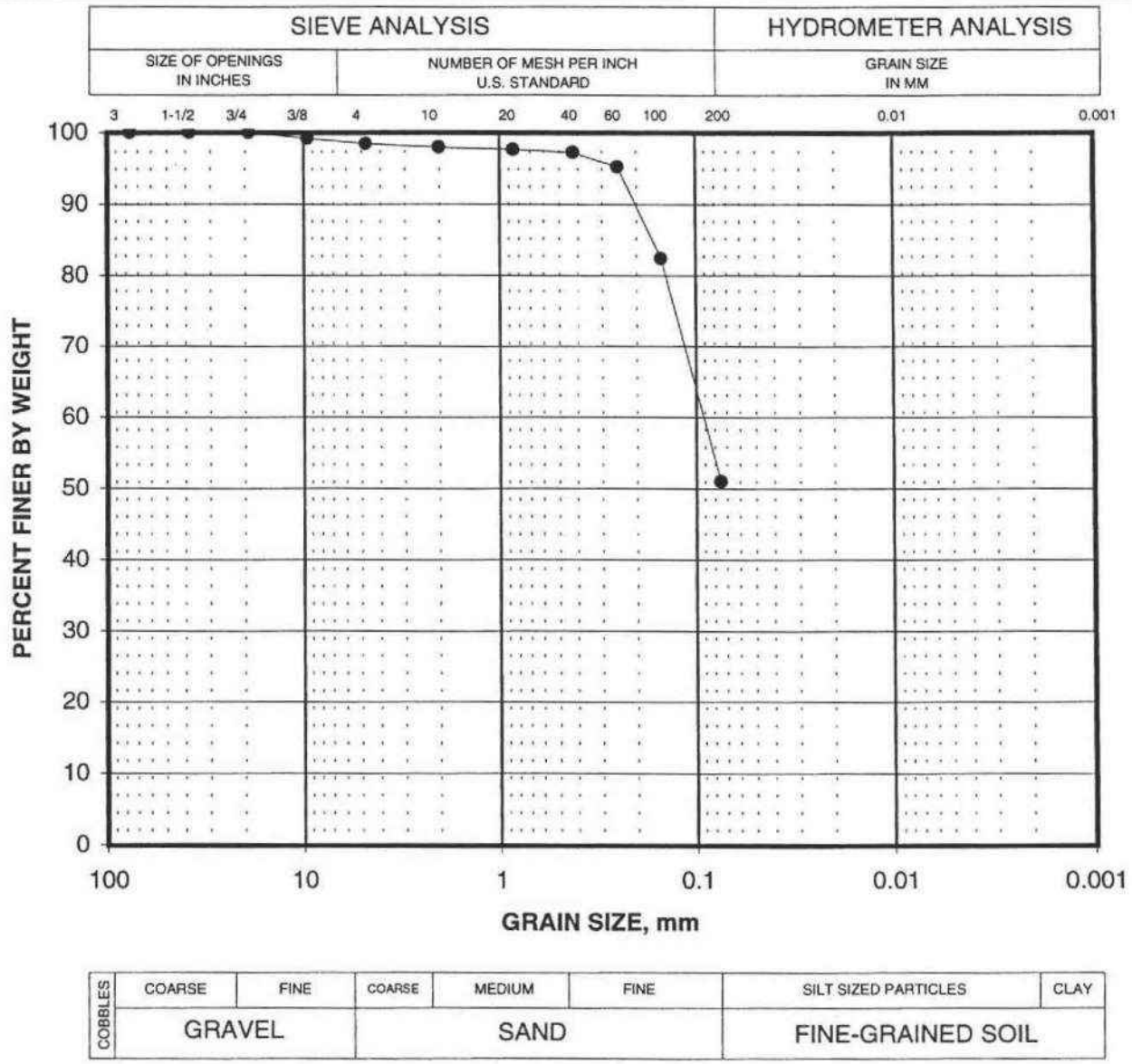
Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-3	Calc. By/Date	AR 6/23/98
Sample	S-3	Check. By/Date	MES 9/9/98
Depth, ft.	15		

CLASSIFICATION:

Brown fine sandy SILT; trace gravel

USCS Classification: ML



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D8

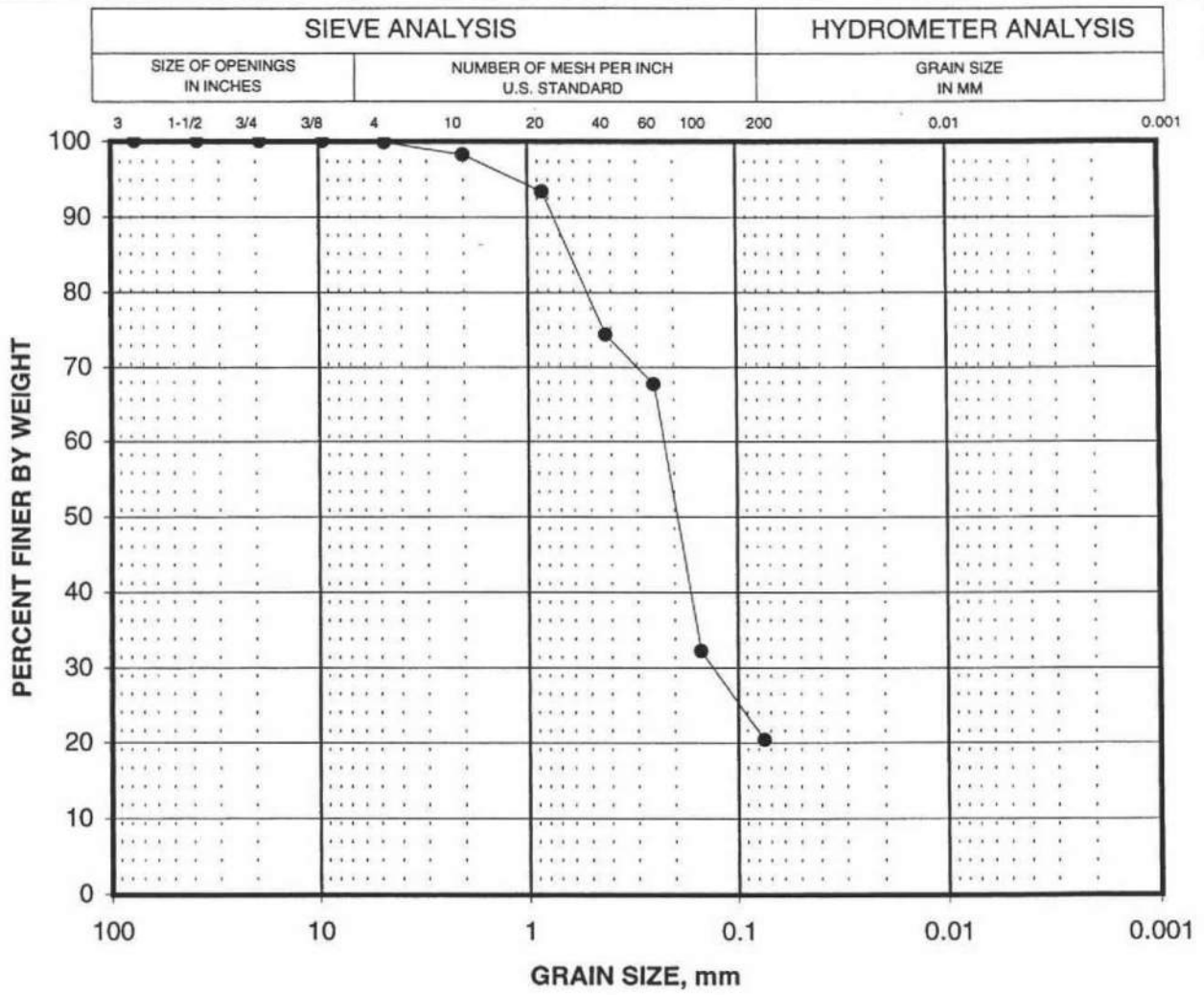
MA

Mechanical Analysis (Sieve Test)

Job No.	98344.1	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-4	Calc. By/Date	AR 6/23/98
Sample	S-4	Check. By/Date	MFS 9/9/98
Depth, ft.	15		

CLASSIFICATION:
Brown silty fine SAND

USCS Classification: SM



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D9

MA

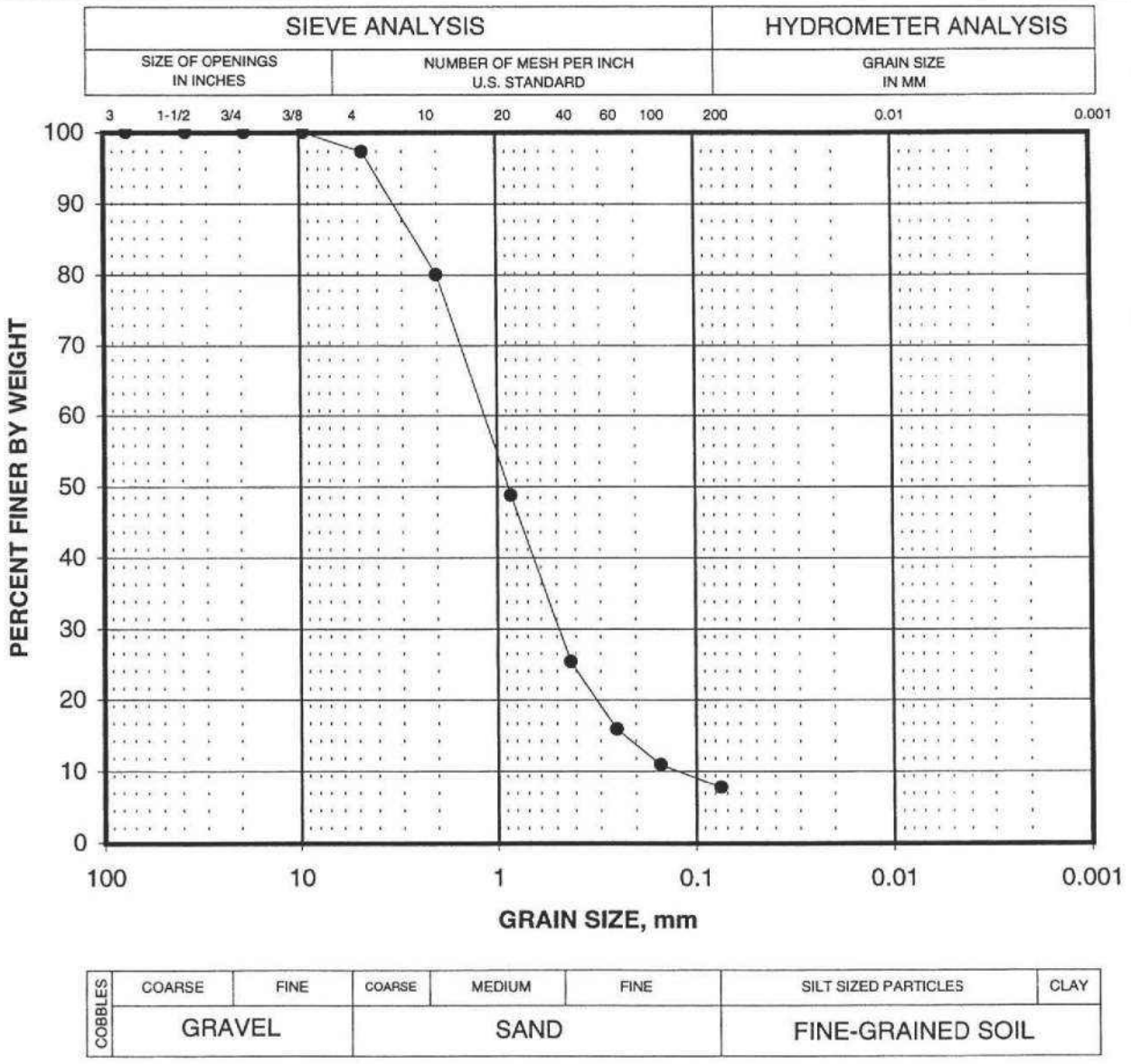
Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-8	Calc. By/Date	AR 6/23/98
Sample	S-8	Check. By/Date	MES 9/9/98
Depth, ft.	35		

CLASSIFICATION:

Brown well graded fine to coarse SAND with silt; trace gravel

USCS Classification: SW-SM



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D10

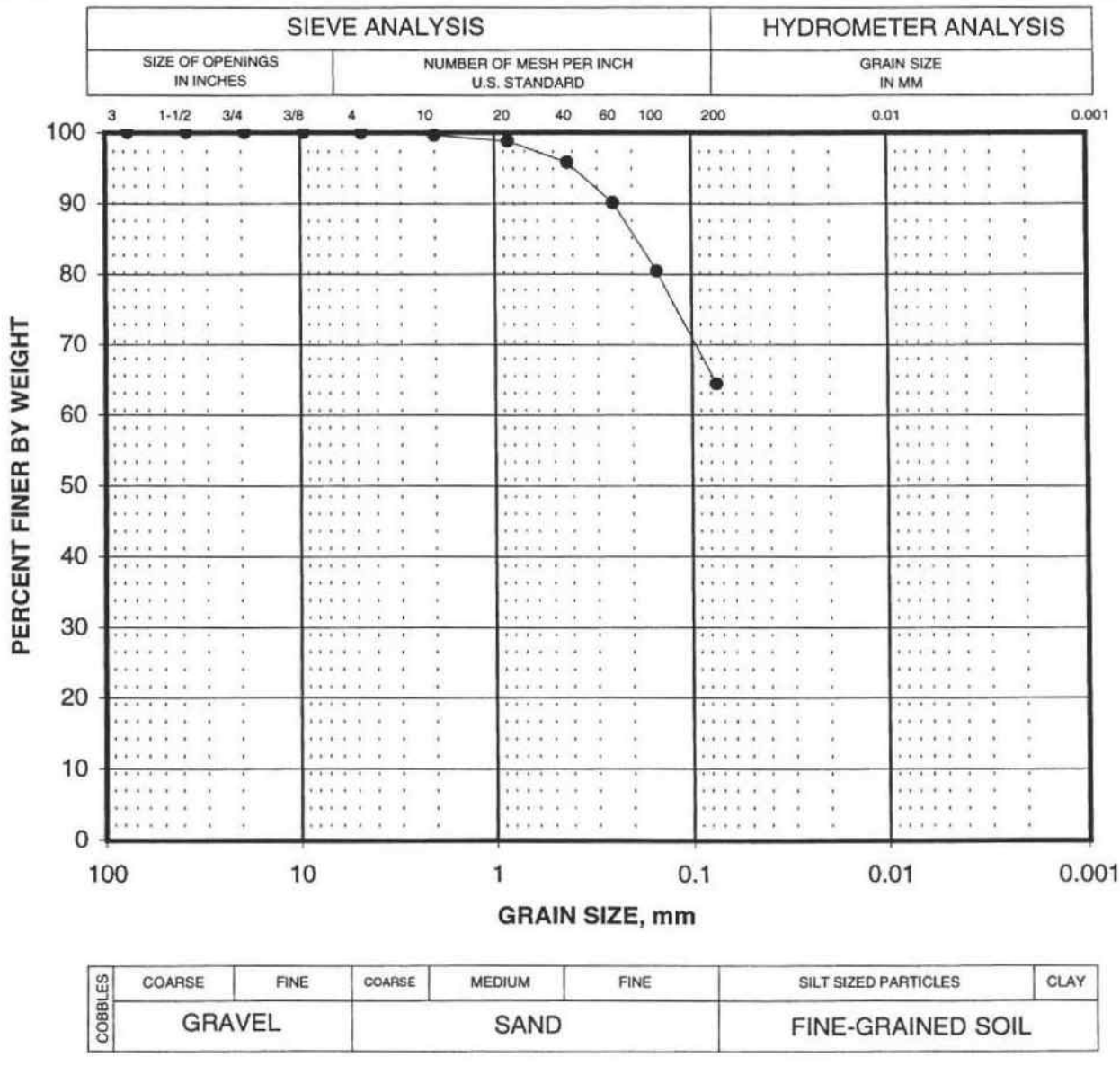
MA

Mechanical Analysis (Sieve Test)

Job No.	98344	Tested By/Date:	AR 6/17/98
Boring/Test Pit	BH-8	Calc. By/Date	AR 6/23/98
Sample	S-13	Check. By/Date	MFS 9/9/98
Depth, ft.	55		

CLASSIFICATION:
Brown fine sandy SILT

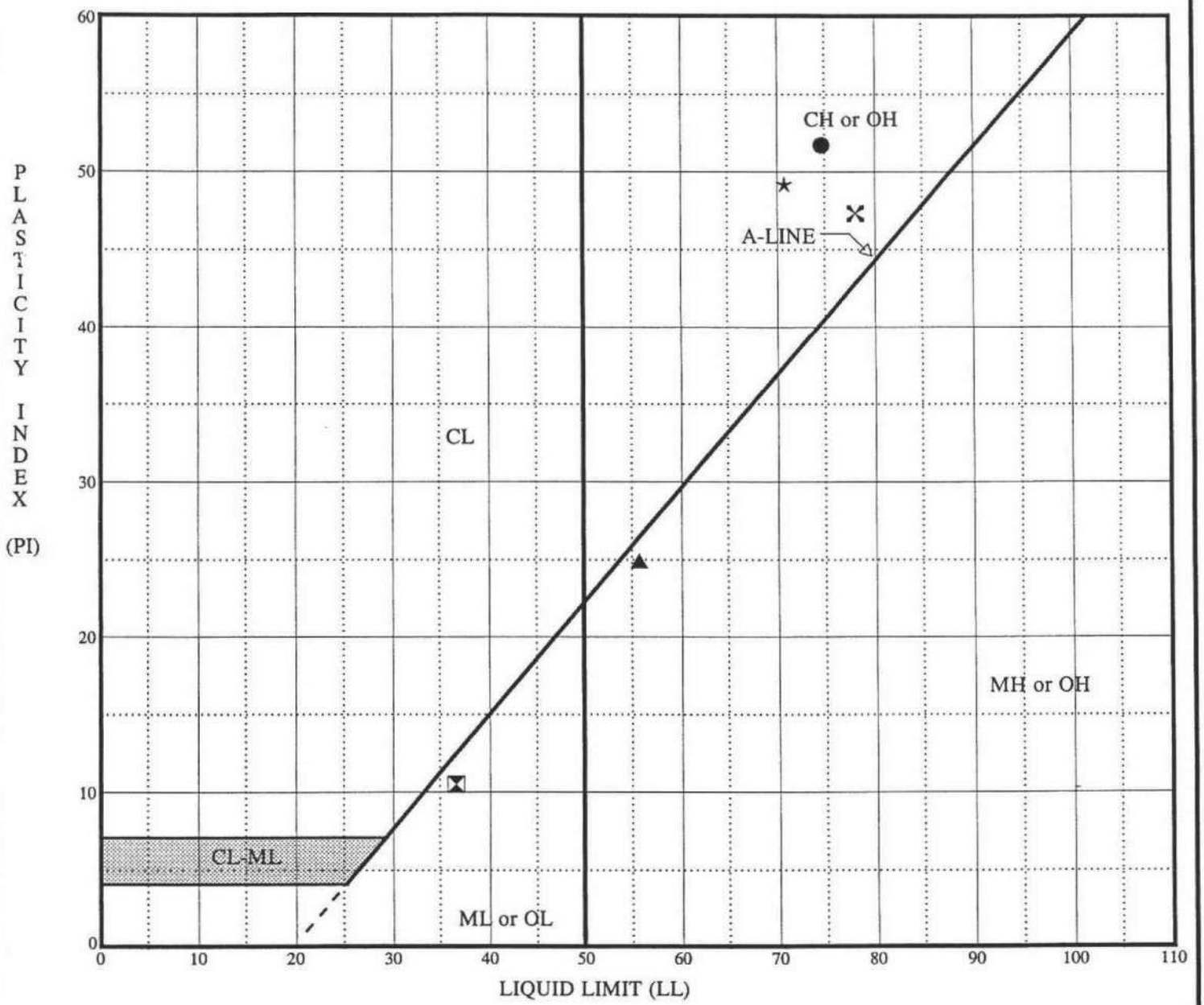
USCS Classification: ML



SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**MA**

HARTCROWSER

FIGURE D11



TP-/B-	SAMPLE	DEPTH, FT.	GEOL. UNIT	LL	PL	PI	WC%	CLASSIFICATION
● BH- 1	S-9	45.0	CH	74.5	22.8	51.7	32.6	Gray-green CLAY with silt
⊠ BH- 2	S-9	35.0	ML	36.5	26.0	10.5	37.8	Brown SILT with clay
▲ BH- 3	S-11	55.0	MH	55.6	30.7	24.9	34.8	Blue-gray clayey SILT
★ BH- 4	S-10	40.0	CH	70.7	21.5	49.2	31.3	Gray-green CLAY with silt
✕ BH- 6	S-6	24.6	CH	78.0	30.7	47.3	43.7	Dark gray CLAY with silt

GROUP	USC CLASSIFICATION Fine-Grained Soil Groups
OL	Organic Silts & Organic Silty Clays of Low Plasticity
ML	Inorganic Clayey Silts to Very Fine Sands of Slight Plasticity
CL	Inorganic Clays--Low to Medium Plasticity
OH	Organic Clays--Medium to High Plasticity, Organic Silts
MH	Inorganic Silts and Clayey Silts
CH	Inorganic Clays of High Plasticity

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Limit
WC% = Water Content, %

Durahm AWWTP

PLASTICITY CHART ATTERBERG LIMITS

SQUIER ASSOCIATES
AUGUST 1998 98344

Reviewed MPS 9/9/98

HARTCROWSER

FIGURE D12

UND

Shelby Tube Density Calculations

Job No. 98344

Tested By/Date: MFS 7/2/98
Calc. By/Date MFS 7/14/98
Check. By/Date MFS 9/9/98

Specimen Data:

Boring No.	BH-2	BH-4	BH-6	BH-1	BH-1
Sample No.	S-5	S-1	S-3	S-14	S-11
Depth (ft)	20-22	5.0-7.0	11.5-13.0	70-71	55-57
Wt.Tube + Wet (g)	1335.1	1344.6	1350.7	1214.4	1393.3
Wt.Tube (g)	340.1	337.4	338.7	308.8	337.9
Length of Tube (in.)	4.98	4.82	4.84	4.40	4.84
Diameter of Tube (in.)	2.85	2.85	2.85	2.85	2.85

Moisture Content Determination:

Tare #	#18	#5	#20	#1	#4
Wt.Tare + Wet (grams)	1080.7	759.5	1119.5	945.3	1180.7
Wt.Tare + Dry (grams)	856.1	631.8	914.5	753.3	990
Wt.Tare (grams)	93	165.7	122.4	83.3	167.5
Water Content (%)	29.43	27.40	25.88	28.66	23.19

Unit Weight (Lbs/cu.ft):

Unit Wet WT. (lbs/cu.ft)	**119.31**	**124.79**	**124.86**	**122.91**	**130.22**
Unit Dry WT. (lbs/cu.ft)	**92.18**	**97.95**	**99.19**	**95.53**	**105.71**

SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**UND**

HARTCROWSER

FIGURE D13

UND

Shelby Tube Density Calculations

Job No. 98344

Tested By/Date: MFS 6/25/98
Calc. By/Date AR 6/26/98
Check. By/Date

Specimen Data:

Boring No.	BH-4	BH-2	BH-7	BH-7	BH-8
Sample No.	S-7	S-2	S-5	S-2	S-2
Depth (ft)	30-32	10-11.7	20-22.25	10-12	10-12
Wt.Tube + Wet (g)	1219.7	1416.8	1271.7	1245.6	1330.5
Wt.Tube (g)	330.5	341.3	342.1	325.7	341.3
Length of Tube (in.)	4.68	4.94	4.8	4.56	4.82
Diameter of Tube (in.)	2.85	2.85	2.85	2.85	2.85

Moisture Content Determination:

Tare #	#10	#4	#8	#3	#6
Wt.Tare + Wet (grams)	1044.5	1023.6	1037.8	983.7	1065.3
Wt.Tare + Dry (grams)	881.2	884.3	823.1	796.7	886.5
Wt.Tare (grams)	210.8	167.4	150.7	83.2	164.3
Water Content (%)	24.36	19.43	31.93	26.21	24.76

Unit Weight (Lbs/cu.ft):

Unit Wet WT. (lbs/cu.ft)	**113.46**	**130.01**	**115.65**	**120.47**	**122.56**
Unit Dry WT. (lbs/cu.ft)	**91.24**	**108.86**	**87.66**	**95.45**	**98.24**

SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**UND**

HARTCROWSER

FIGURE D14

UND

Shelby Tube Density Calculations

J.O.	98344	Tested By/Date:	MFS 7/2/98
		Calc. By/Date	MFS 7/14/98
		Check. By/Date	MFS 9/9/98

Specimen Data:

Boring No.	BH-8	BH-6
Sample No.	S-12	S-6
Depth (ft)	55-57	23.5-25.5
Wt.Tube + Wet (g)	1364.5	1259.6
Wt.Tube (g)	341.2	342.3
Length of Tube (in.)	4.8	4.84
Diameter of Tube (in.)	2.85	2.85

Moisture Content Determination:

Tare #	#10	A-12
Wt.Tare + Wet (grams)	1196.3	315.7
Wt.Tare + Dry (grams)	998.6	277.1
Wt.Tare (grams)	210.8	188.7
Water Content (%)	25.10	43.67

Unit Weight (Lbs/cu.ft):

Unit Wet WT. (lbs/cu.ft)	**127.31**	**113.18**
Unit Dry WT. (lbs/cu.ft)	**101.77**	**78.78**

UIER ASSOCIATES	PROJECT: **Durham AWWTP**	**UND**

HARTCROWSER

FIGURE D15

DS

DIRECT SHEAR TEST

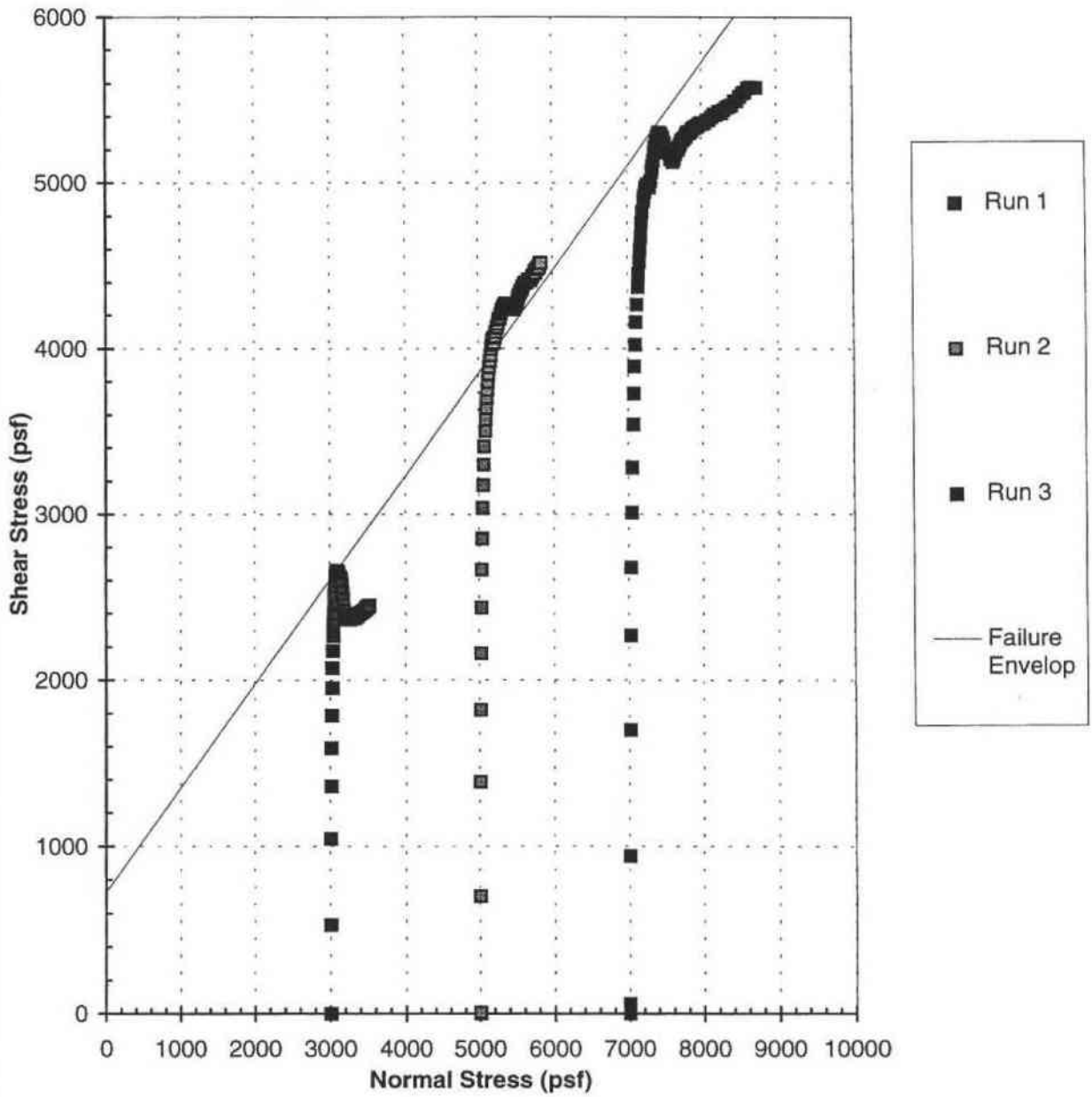
Peak

Shear Stress v. Normal Stress Plot

Job No.	98344
Boring/Test Pit	BH-1
Sample	S-11
Depth, ft.	56

Peak Shear Strength Parameters:

phi' = 32.0 degrees
c' = 725 psf



SQUIER ASSOCIATES	PROJECT: Durham AWWTP	DS

HARTCROWSER

FIGURE D16

DS

DIRECT SHEAR TEST

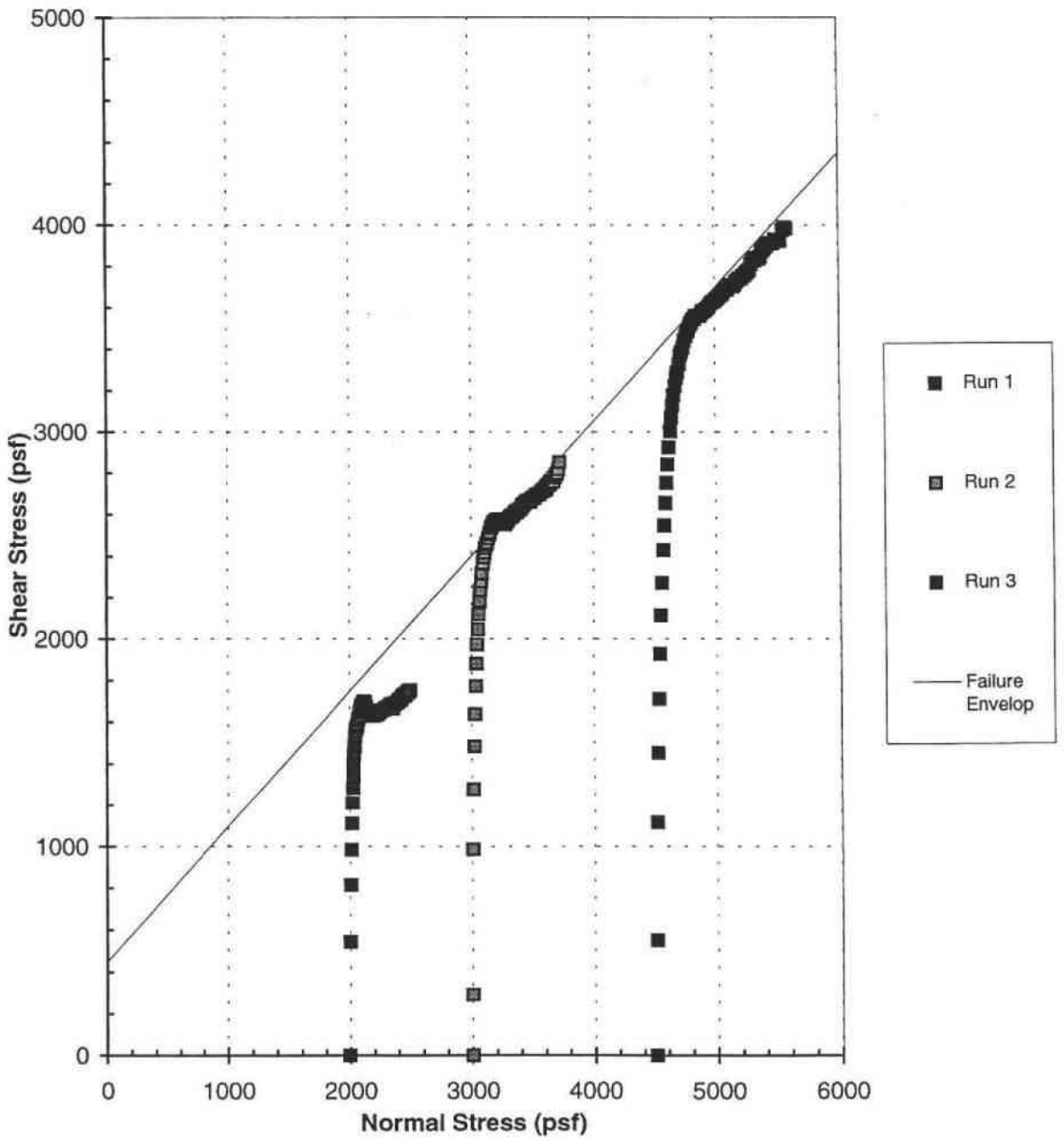
Peak

Shear Stress v. Normal Stress Plot

Job No.	98344
Boring/Test Pit	BH-2
Sample	S-5
Depth, ft.	21.3

Peak Shear Strength Parameters:

phi' = 33.0 degrees
c' = 450 psf



SQUIER ASSOCIATES	PROJECT: Durham AWWTP	DS

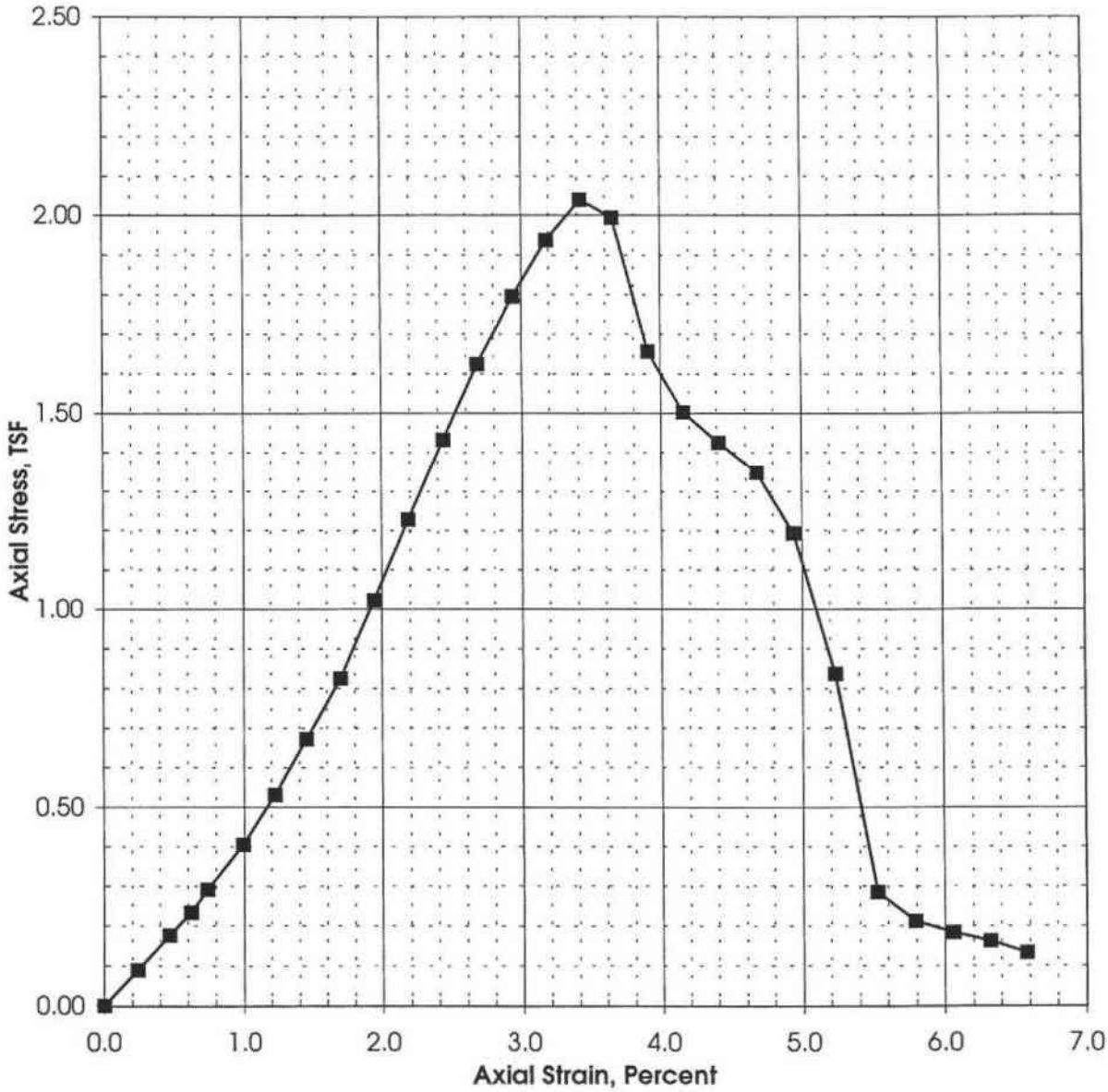
FIGURE D17

Qu

UNCONFINED COMPRESSION TEST

Stress vs. Strain Plot

Job No.	98344
Boring/Test Pit	BH-1
Sample	S-11
Depth, ft.	55.1 - 55.6



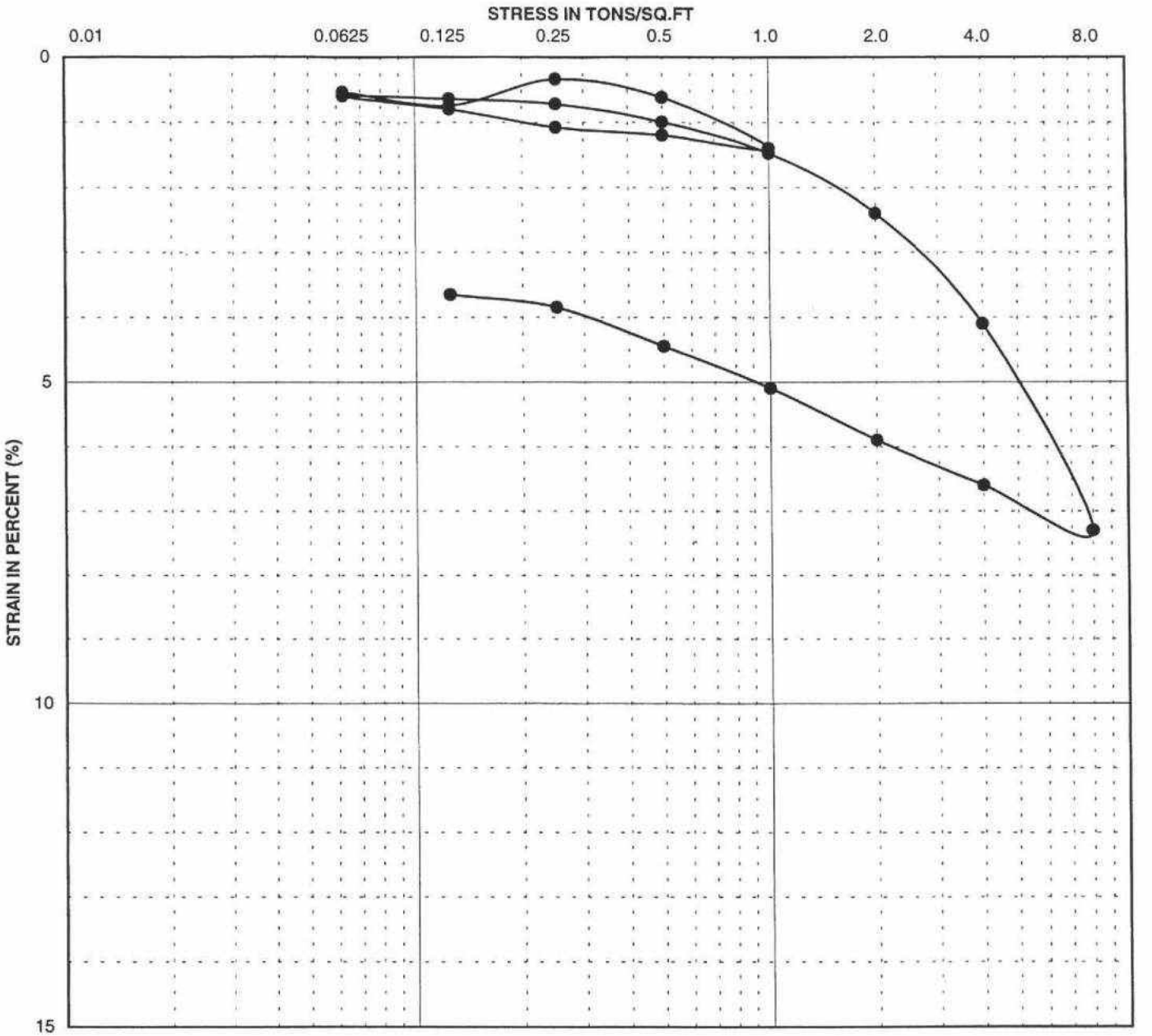
SQUIER ASSOCIATES	PROJECT: **Durham AWWTP**	**Qu**

HARTCROWSER

FIGURE D18

CONSOL

Consolidation Test



STRESS vs. STRAIN

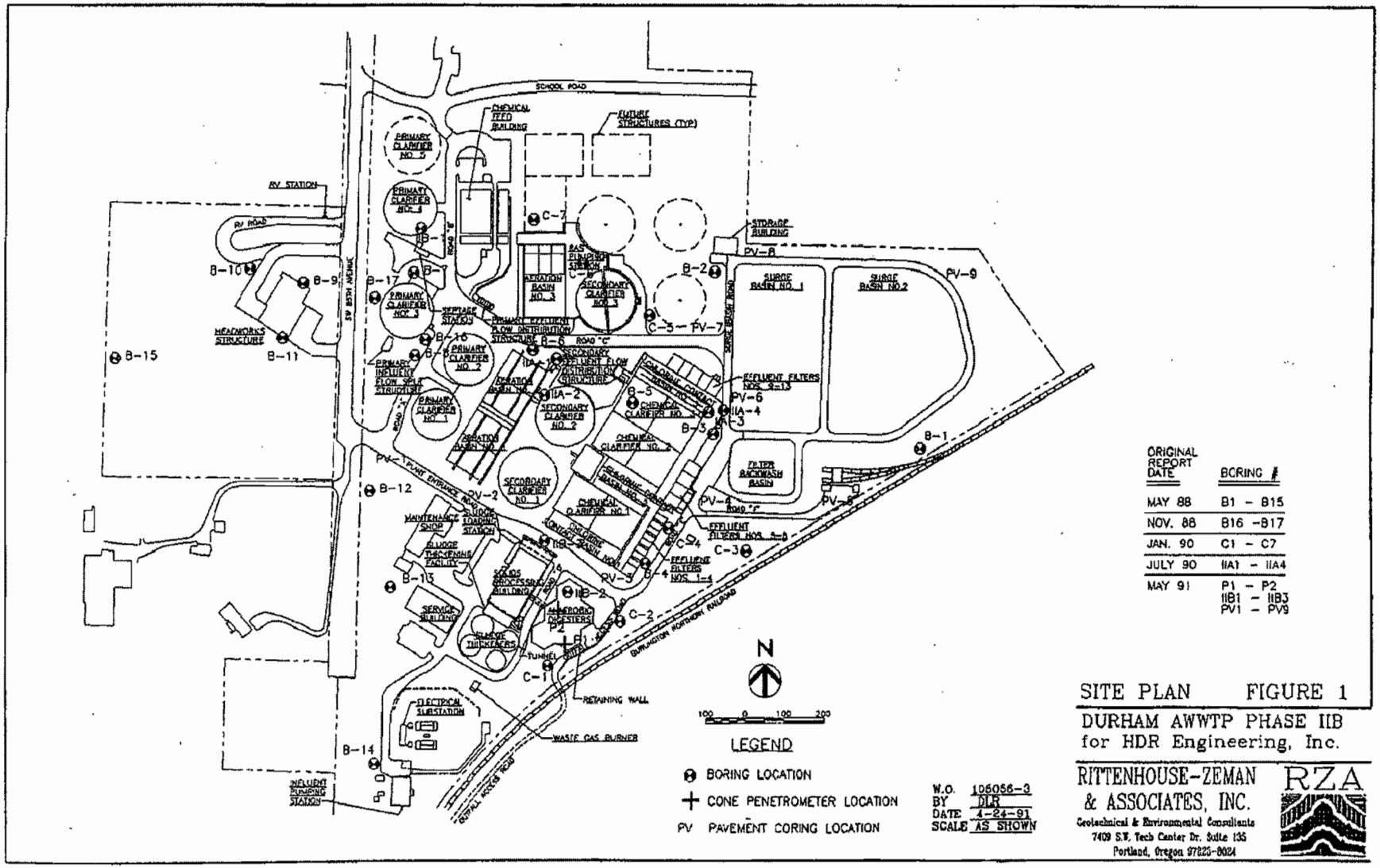
Test Symbol	Boring/ Test Pit	Sample	Depth (feet)	W(%) Before	W(%) After	Height (inches)	Diameter (inches)	Classification of Material
●	B-6	S-6	24.6	43.7	40.4	1.0	2.5	Very stiff gray green CLAY with silt (CH)

UIER ASSOCIATES | PROJECT: **Durham AWWTP** | **CONSOL**

HARTCROWSER

FIGURE D19

Appendix E.5
Durham Advanced Wastewater Treatment Plant Chemical Expansion Project



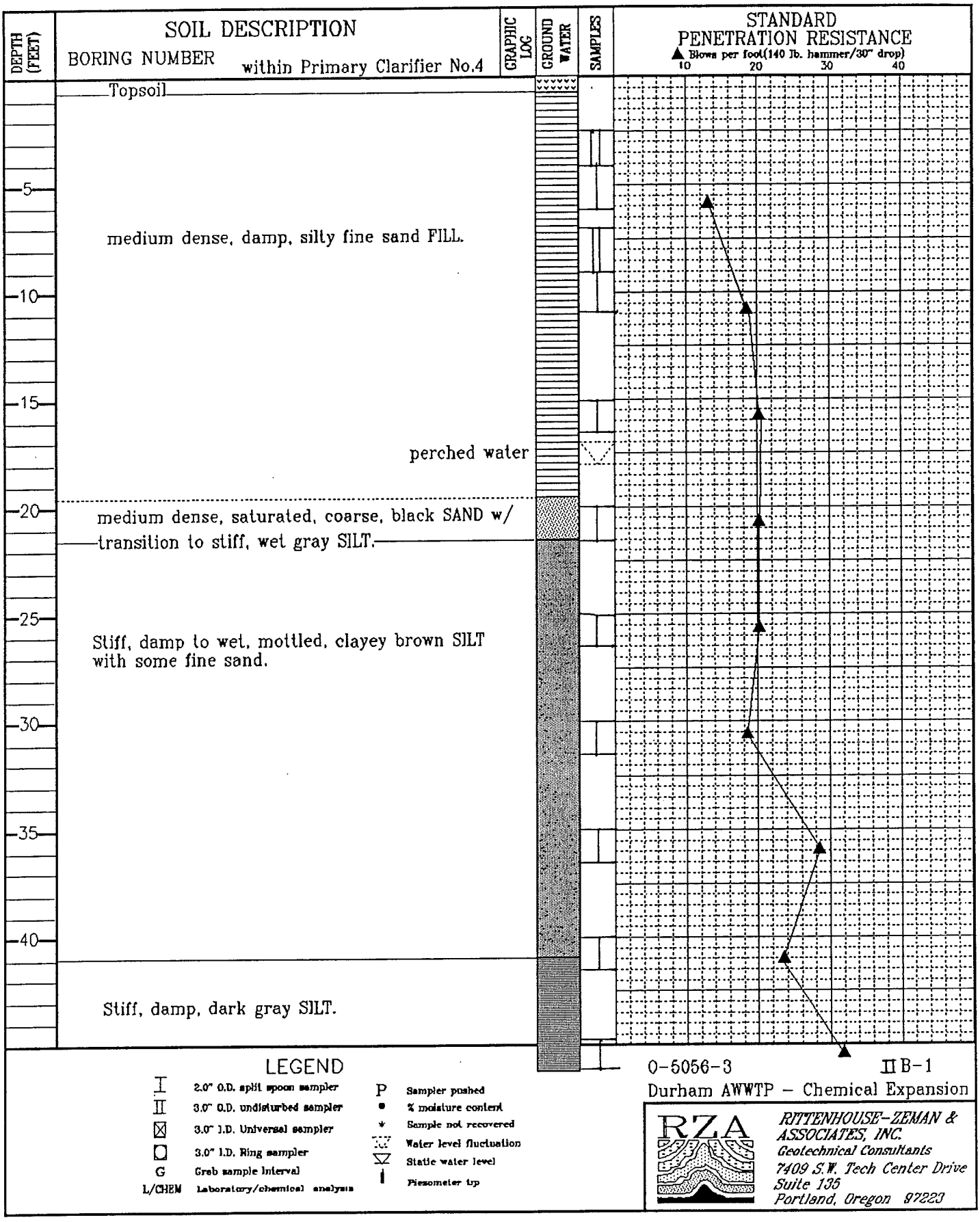
ORIGINAL REPORT DATE	BORING #
MAY 88	B1 - B15
NOV. 88	B16 -B17
JAN. 90	C1 - C7
JULY 90	IIA1 - IIA4
MAY 91	P1 - P2 IIB1 - IIB3 PV1 - PV9

W.O. 105056-3
BY DLR
DATE 4-24-91
SCALE AS SHOWN

SITE PLAN FIGURE 1

DURHAM AWWTP PHASE IIB
for HDR Engineering, Inc.

RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Environmental Consultants
7409 S.W. Tech Center Dr. Suite 135
Portland, Oregon 97223-8024



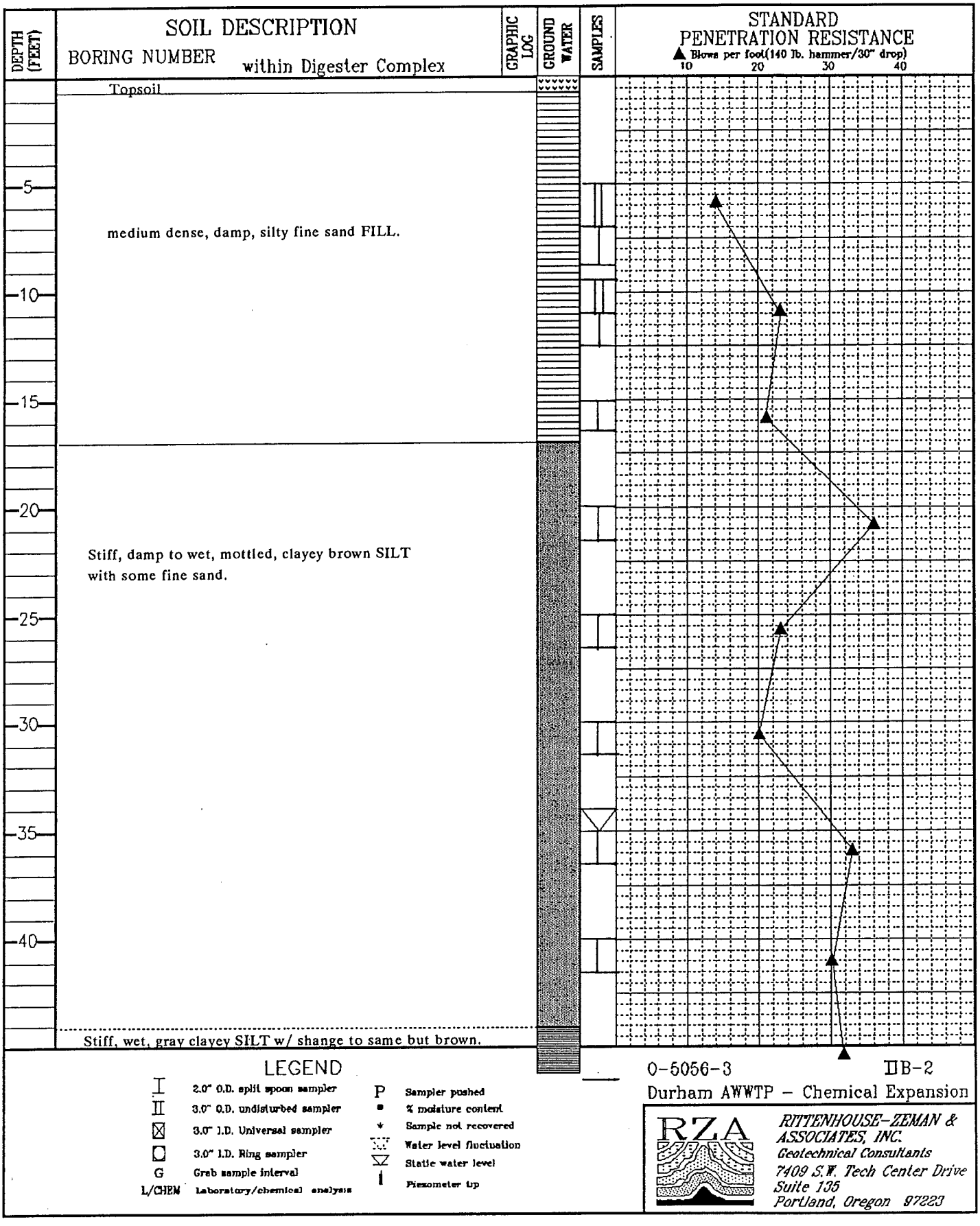
LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	●	% moisture content
⊠	3.0" I.D. Universal sampler	*	Sample not recovered
☐	3.0" I.D. Ring sampler		Water level fluctuation
G	Grab sample interval		Static water level
L/CHEM	Laboratory/chemical analysis		Piezometer tip

0-5056-3 II B-1

Durham AWWTP – Chemical Expansion

RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical Consultants
7409 S.W. Tech Center Drive
Suite 135
Portland, Oregon 97223



LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	■	% moisture content
⊠	3.0" I.D. Universal sampler	⚰	Sample not recovered
▢	3.0" I.D. Ring sampler		Water level fluctuation
G	Grab sample interval	▽	Static water level
L/CHEM	Laboratory/chemical analysis		Piezometer tip

0-5056-3 IIB-2

Durham AWWTP – Chemical Expansion

RZA
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Geotechnical Consultants
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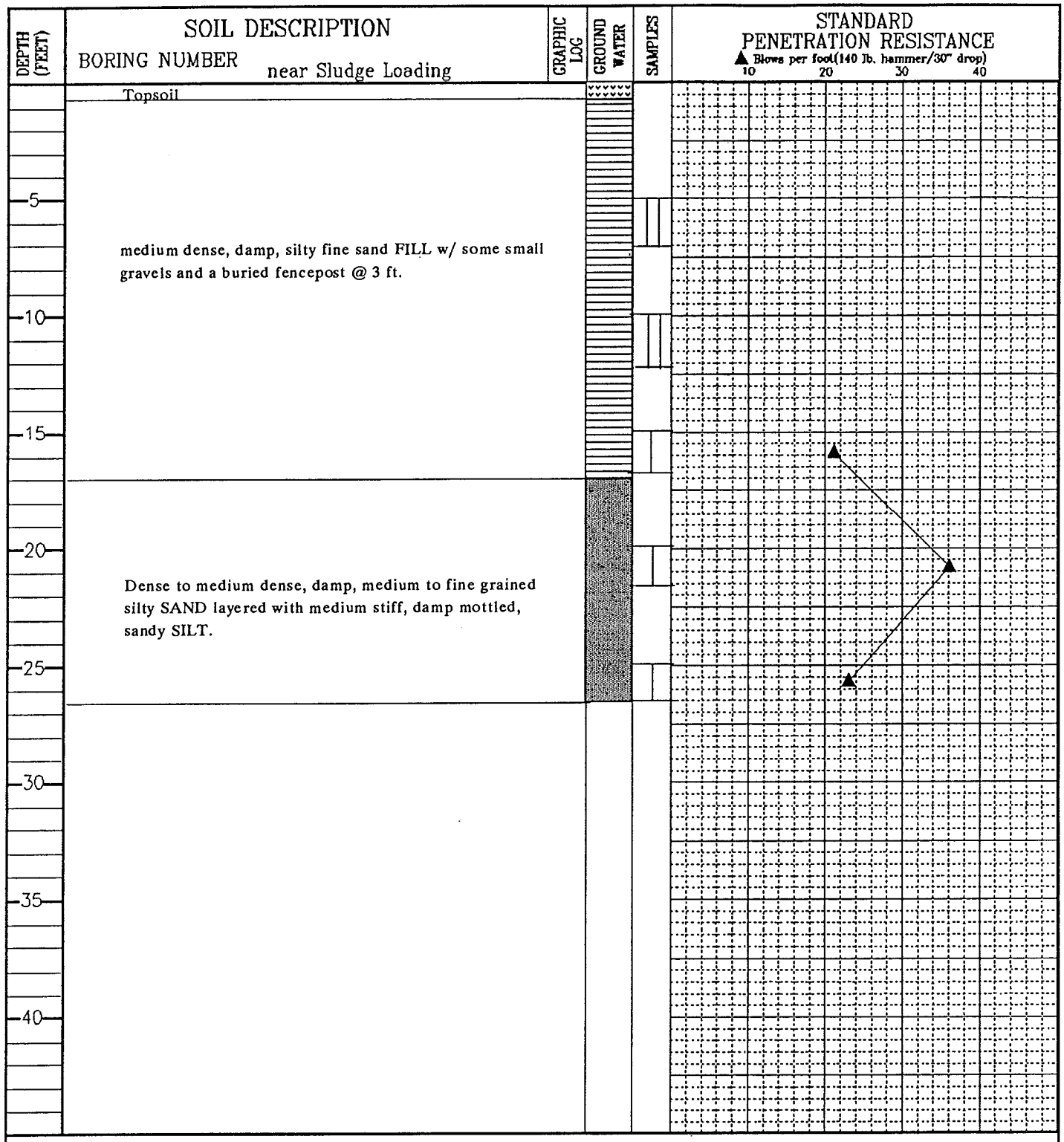
Portland, Oregon 97223



LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	●	% moisture content
⊠	3.0" I.D. Universal sampler	*	Sample not recovered
▢	3.0" I.D. Ring sampler	▽	Water level fluctuation
G	Grab sample interval	▽	Static water level
L/CHEM	Laboratory/chemical analysis	▮	Piezometer tip

0-5056-3 IIB-3

Durham AWWTP – Chemical Expansion

RZA
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Geotechnical Consultants
7409 S.W. Tech Center Drive
Suite 135
Portland, Oregon 97223

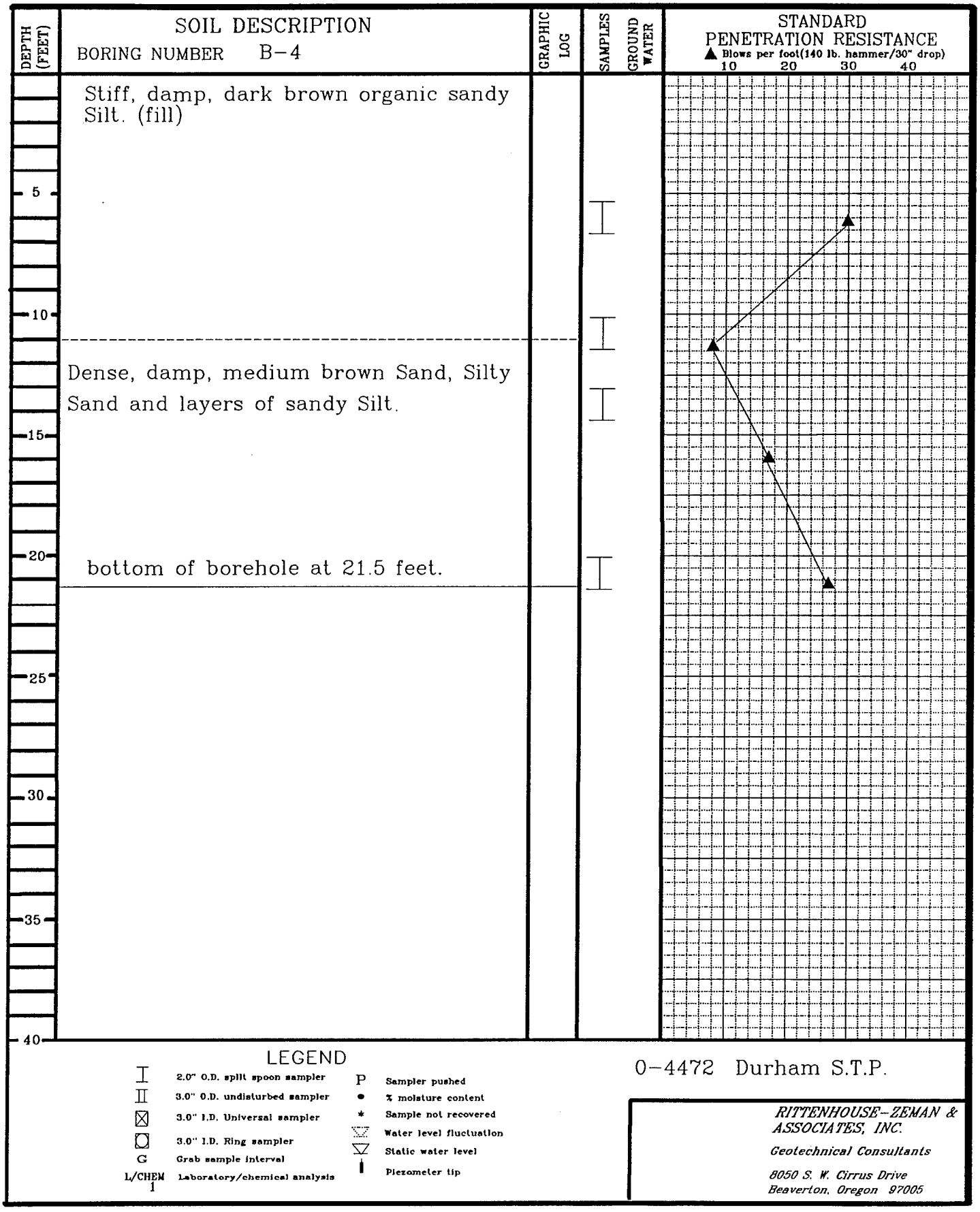
DEPTH (FEET)	SOIL DESCRIPTION BORING NUMBER B-1	GRAPHIC LOG	SAMPLES	GROUND WATER	STANDARD PENETRATION RESISTANCE ▲ Blows per foot(140 lb. hammer/30" drop) 10 20 30 40
	railroad ballast				
5	medium stiff to stiff, damp to wet, medium brown silty sand to sandy silt (fill)		I		
10			I		
15	stiff,damp to wet, gray brown mottled sandy silt with sand layers. perched groundwater present above silt layers.		I		
20	bottom of borehole at 21.5 feet.		I		
25					
30					
35					
40					

LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	●	% moisture content
⊠	3.0" I.D. Universal sampler	*	Sample not recovered
◯	3.0" I.D. Ring sampler	▽	Water level fluctuation
G	Grab sample interval	▽	Static water level
L/CHEM 1	Laboratory/chemical analysis		Piezometer tip

0-4472 Durham S.T.P.

RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical Consultants
8050 S. W. Cirrus Drive
Beaverton, Oregon 97005


DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-4
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Stiff, damp, dark brown organic sandy Silt. (fill)
Dense, damp, medium brown Sand, Silty Sand and layers of sandy Silt.
bottom of borehole at 21.5 feet.
5
10
15
20
25
30
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM Laboratory/chemical analysis
P Sampler pushed
% moisture content
* Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
0-4472 Durham S.T.P.
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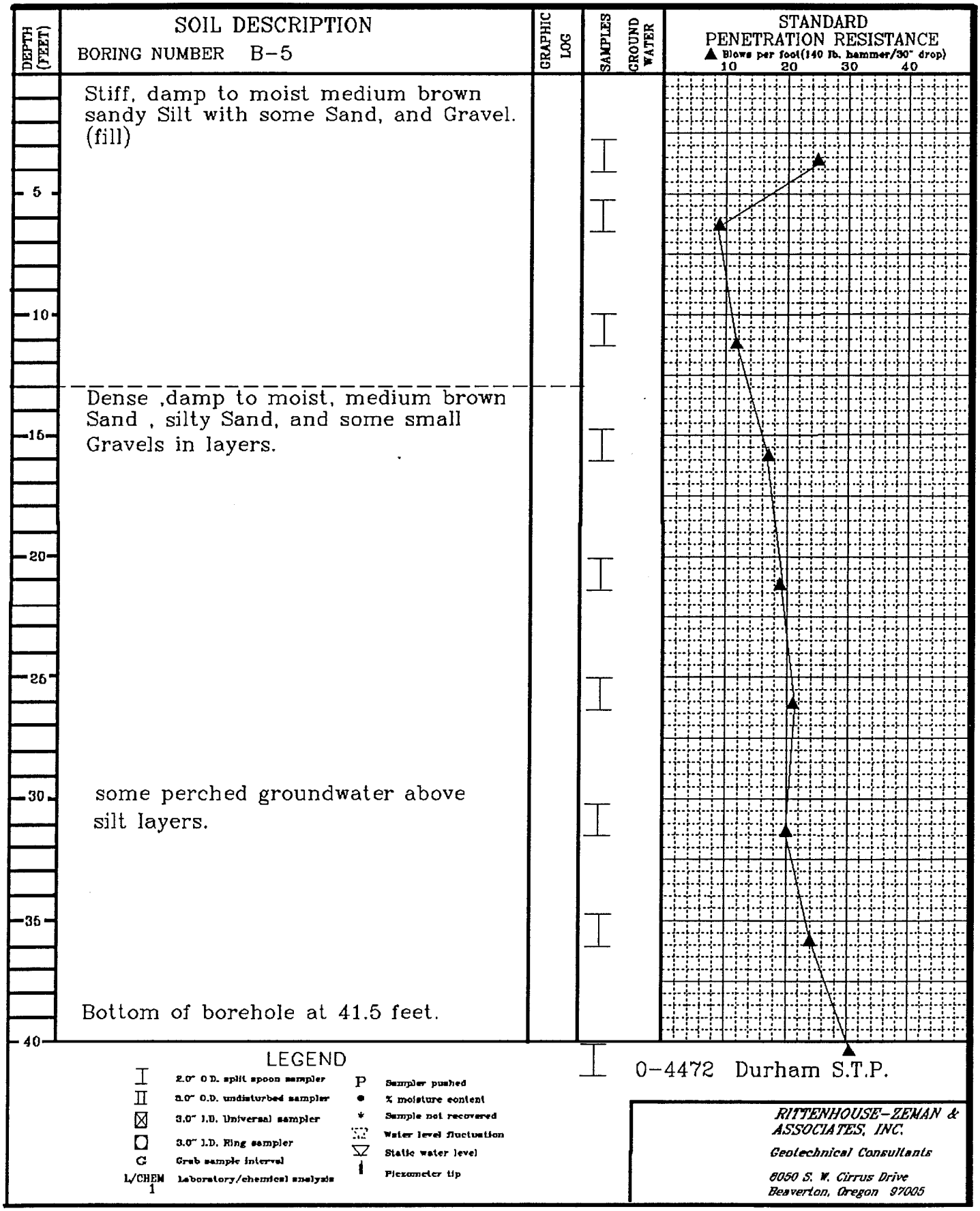
DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-5
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Stiff, damp to moist medium brown sandy Silt with some Sand, and Gravel. (fill)
5
10
Dense ,damp to moist, medium brown Sand , silty Sand, and some small Gravels in layers.
15
20
25
some perched groundwater above silt layers.
30
35
Bottom of borehole at 41.5 feet.
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM 1 Laboratory/chemical analysis
P Sampler pushed
% moisture content
* Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
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DEPTH (FEET)	SOIL DESCRIPTION BORING NUMBER B-6	GRAPHIC LOG	SAMPLES	GROUND WATER	STANDARD PENETRATION RESISTANCE ▲ Blows per foot(140 lb. hammer/30" drop) 10 20 30 40
5	Stiff to very stiff, damp, medium reddish brown Silt. (fill)				
10	Dense to very dense, light to medium brown, damp, silty Sand, and Sand in layers.				
15					
20	Bottom of borehole at 21.5 feet.				
25					
30					
35					
40					

LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	●	% moisture content
⊠	3.0" I.D. Universal sampler	⸸	Sample not recovered
▢	3.0" I.D. Ring sampler	▽	Water level fluctuation
G	Grab sample interval	▽	Static water level
L/CHEM 1	Laboratory/chemical analysis		Piezometer tip

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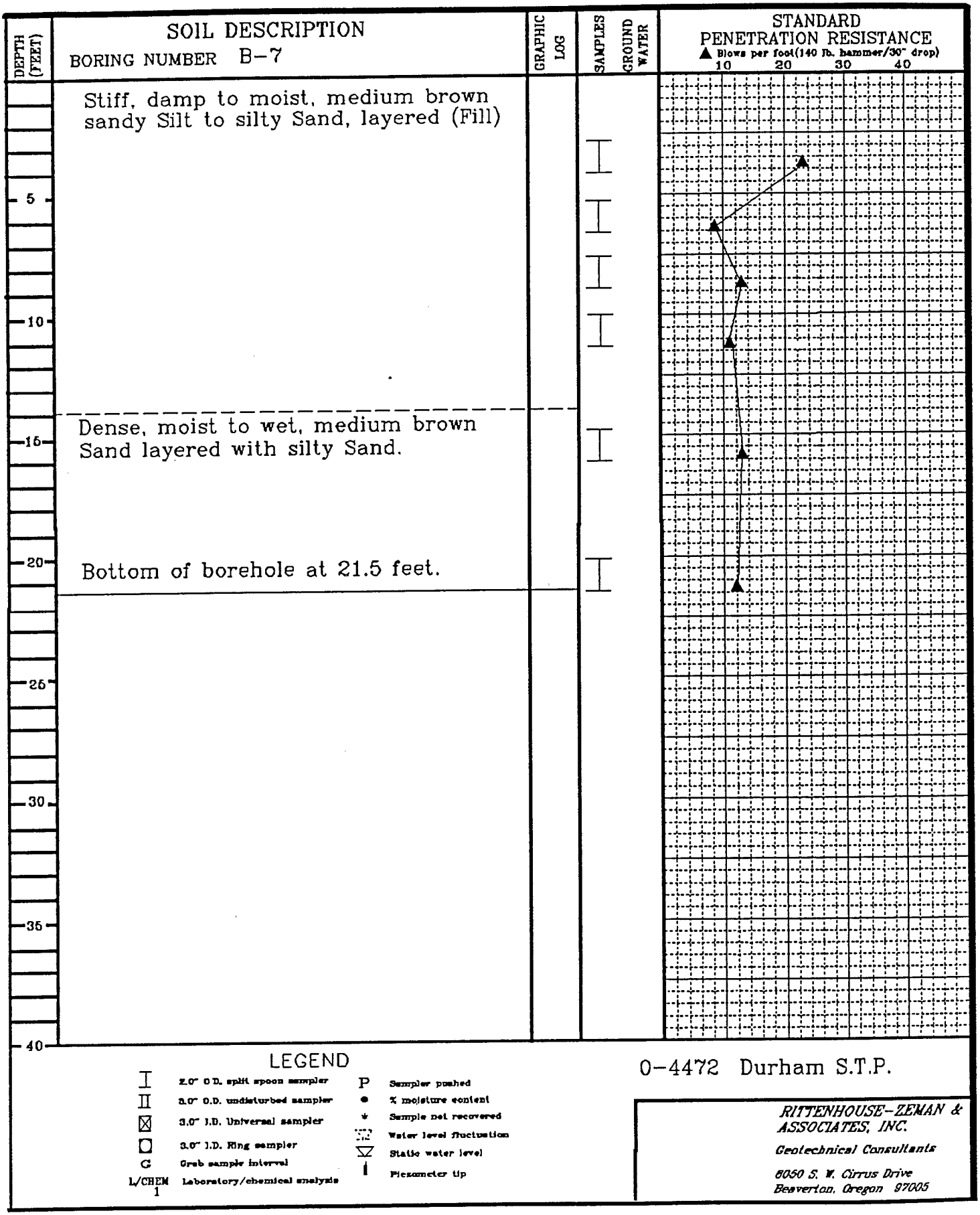

LEGEND

- I — 2.0" O.D. split spoon sampler
- II — 3.0" O.D. undisturbed sampler
- ⊠ — 3.0" I.D. Universal sampler
- ▢ — 3.0" I.D. Ring sampler
- G — Grab sample interval
- L/CHEM 1 — Laboratory/chemical analysis
- P — Sampler pushed
- ● — % moisture content
- ⊻ — Sample not recovered
- Water level fluctuation
- Static water level
- Piezometer tip

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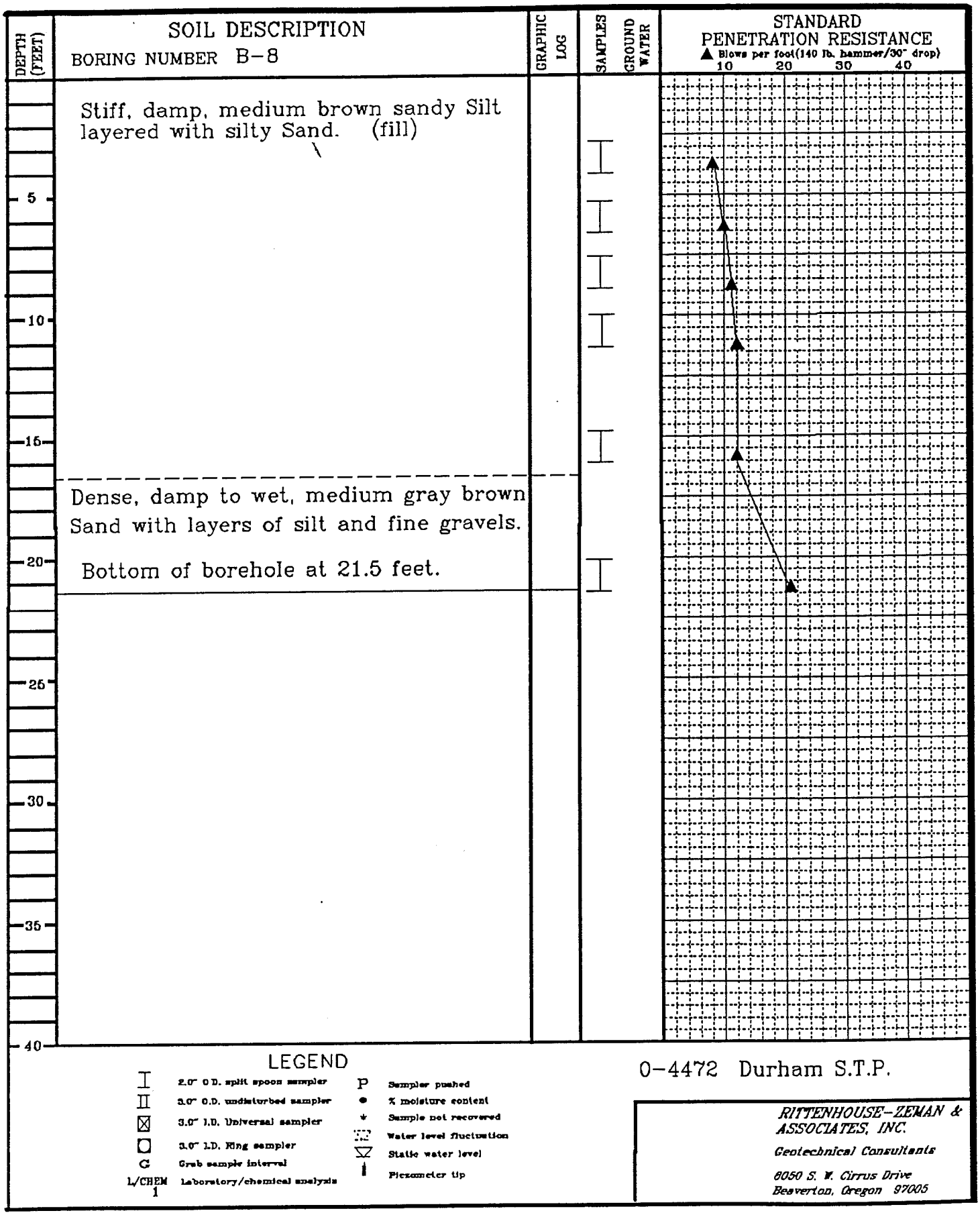

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DEPTH (FEET)	SOIL DESCRIPTION BORING NUMBER B-9	GRAPHIC LOG	SAMPLES	GROUND WATER	STANDARD PENETRATION RESISTANCE ▲ Blows per foot(140 lb. hammer/30" drop) 10 20 30 40
0	Medium stiff, moist medium brown sandy Silt layered with dense, wet, gray brown silty Sand, and clean sand.		I		
5			I		
10			I		
15	stiffer drilling at 17 feet. perched groundwater above silt layers.		I		
20	Bottom of borehole at 21.5 feet.		I		
25					
30					
35					
40					

LEGEND

I	2.0" O.D. split spoon sampler	P	Sampler pushed
II	3.0" O.D. undisturbed sampler	●	% moisture content
⊠	3.0" I.D. Universal sampler	*	Sample not recovered
▢	3.0" I.D. Ring sampler	▽	Water level fluctuation
G	Grab sample interval	▽	Static water level
L/CHEM 1	Laboratory/chemical analysis		Piezometer tip

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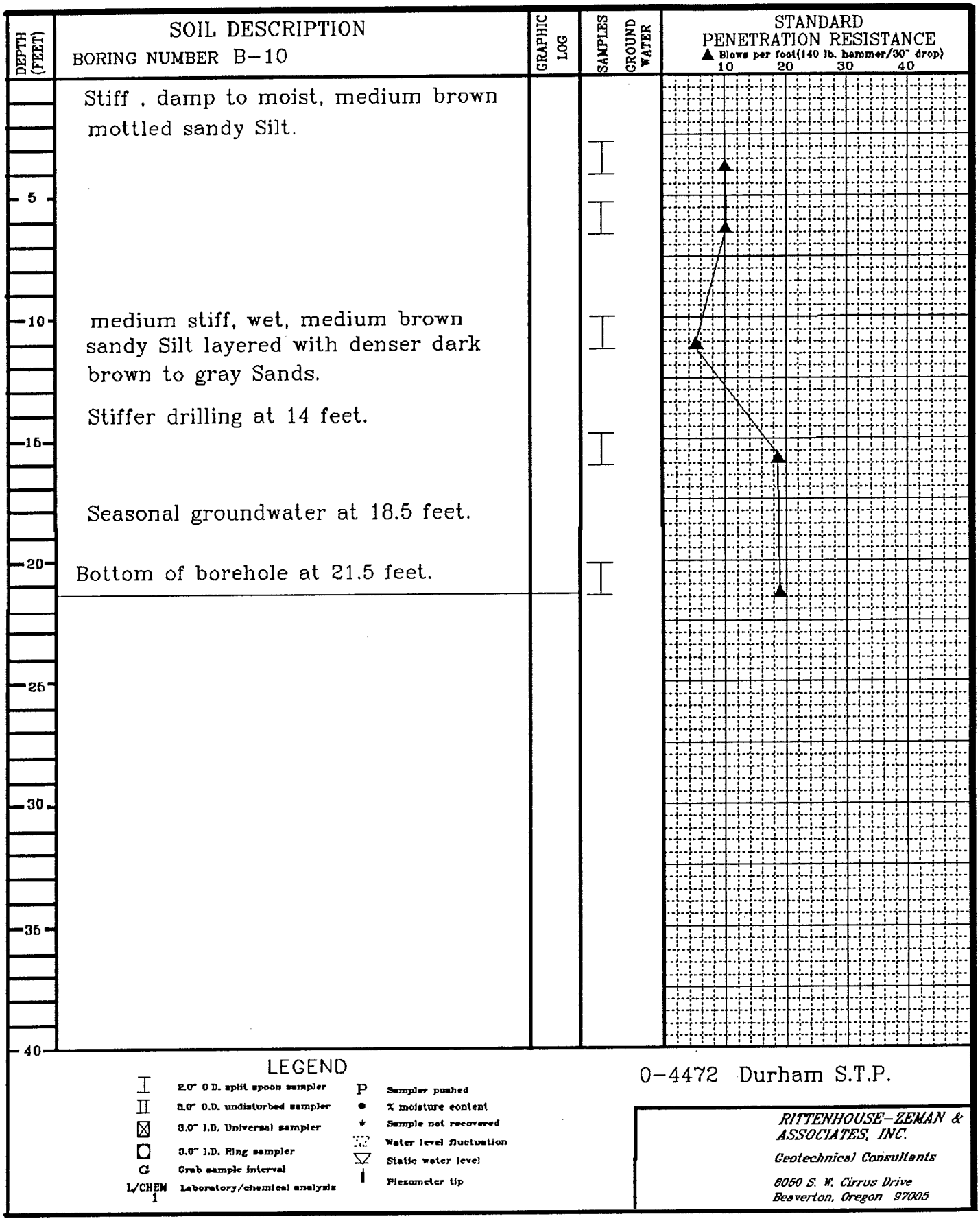
DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-10
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Stiff , damp to moist, medium brown mottled sandy Silt.
5
10
medium stiff, wet, medium brown sandy Silt layered with denser dark brown to gray Sands.
Stiffer drilling at 14 feet.
15
Seasonal groundwater at 18.5 feet.
20
Bottom of borehole at 21.5 feet.
25
30
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM 1 Laboratory/chemical analysis
P Sampler pushed
% moisture content
* Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
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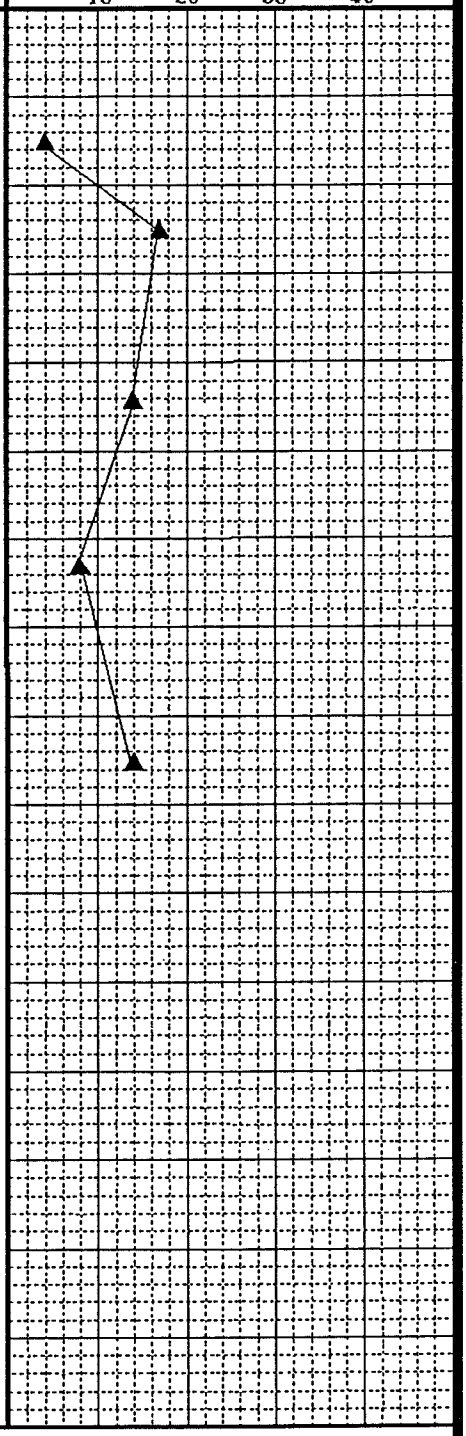
DEPTH (FEET)	SOIL DESCRIPTION BORING NUMBER B-11	GRAPHIC LOG	SAMPLES / GROUND WATER
	Soft ,moist to wet, dark brown organic sandy Silt.		
5	Stiff and/or dense, moist to wet, med. gray brown sandy Silt to silty Sand in layers. Perched groundwater present above silty layers.		
10			
15			
	Dense, wet, dark gray silty sand.		
20	Bottom of borehole at 21.5 feet.		
25			
30			
35			
40			

STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10 20 30 40



LEGEND

- I — 2.0" O.D. split spoon sampler
- II — 3.0" O.D. undisturbed sampler
- ⊠ — 3.0" I.D. Universal sampler
- ▢ — 3.0" I.D. Ring sampler
- G — Grab sample interval
- L/CHEM 1 — Laboratory/chemical analysis
- P — Sampler pushed
- ● — % moisture content
- * — Sample not recovered
- Water level fluctuation
- ▽ — Static water level
- Piezometer tip

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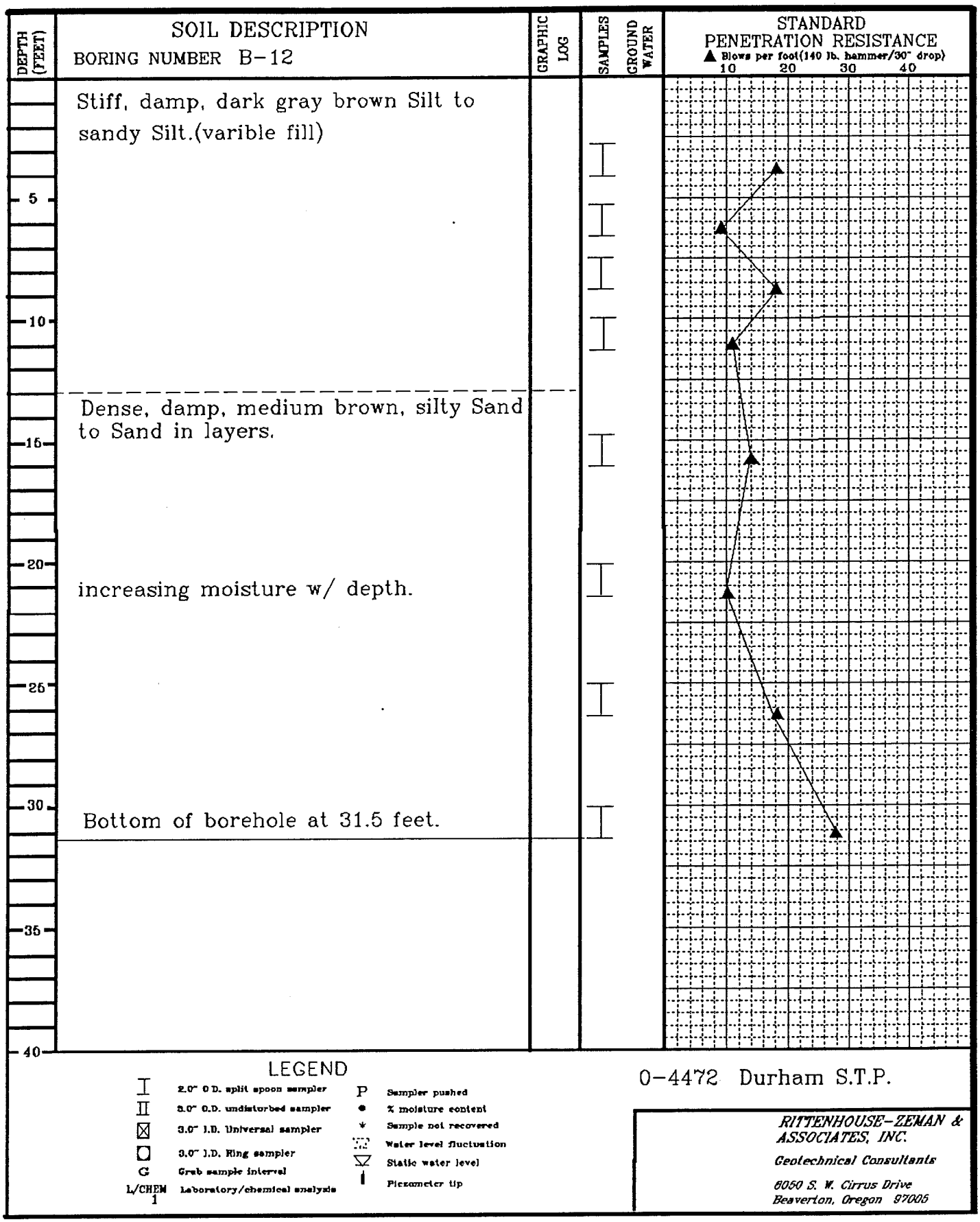
DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-12
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Stiff, damp, dark gray brown Silt to sandy Silt.(varible fill)
5
10
Dense, damp, medium brown, silty Sand to Sand in layers.
15
20
increasing moisture w/ depth.
25
30
Bottom of borehole at 31.5 feet.
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM 1 Laboratory/chemical analysis
P Sampler pushed
% moisture content
Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
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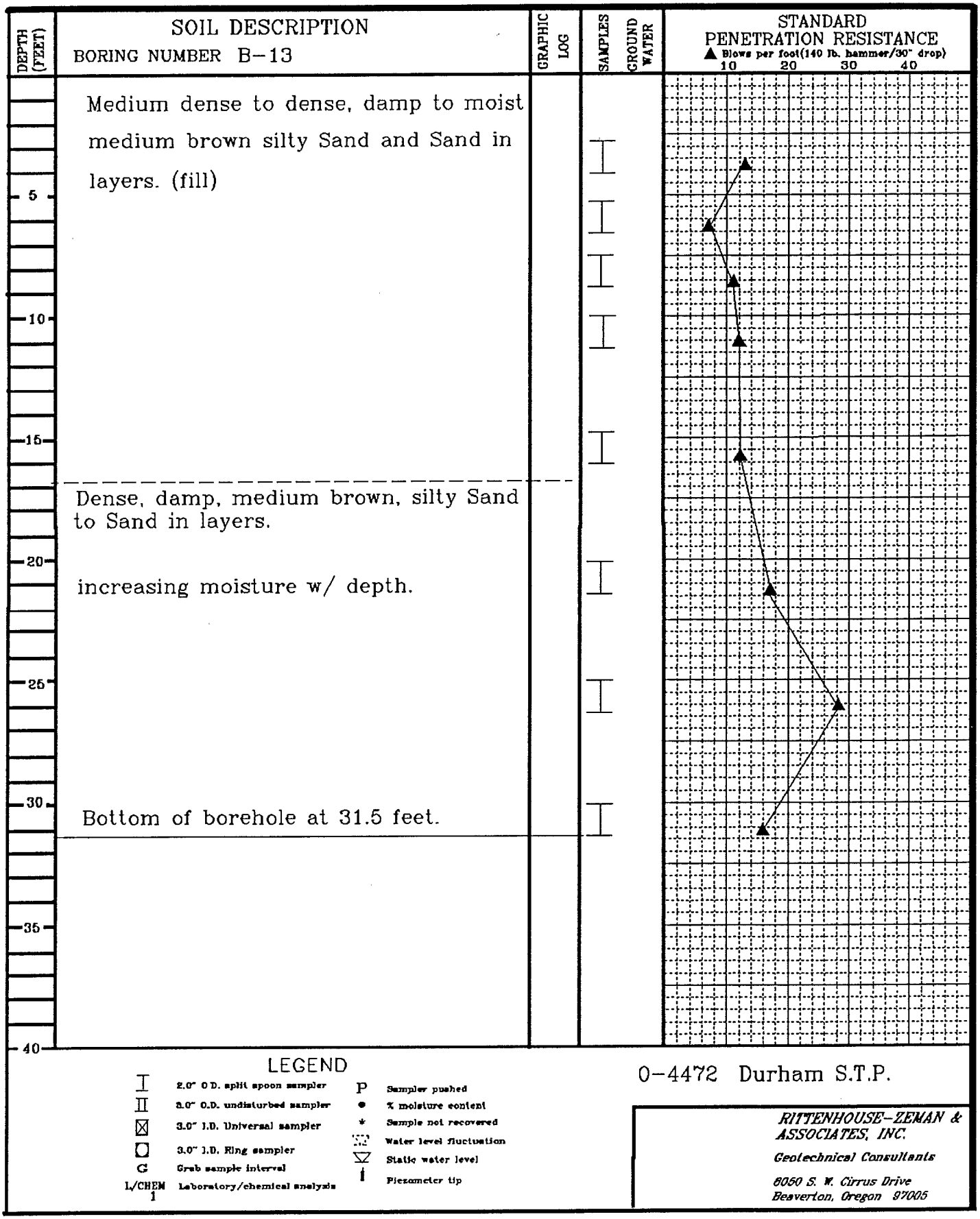
DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-13
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Medium dense to dense, damp to moist medium brown silty Sand and Sand in layers. (fill)
Dense, damp, medium brown, silty Sand to Sand in layers.
increasing moisture w/ depth.
Bottom of borehole at 31.5 feet.
5
10
15
20
25
30
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM Laboratory/chemical analysis
P Sampler pushed
% moisture content
* Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
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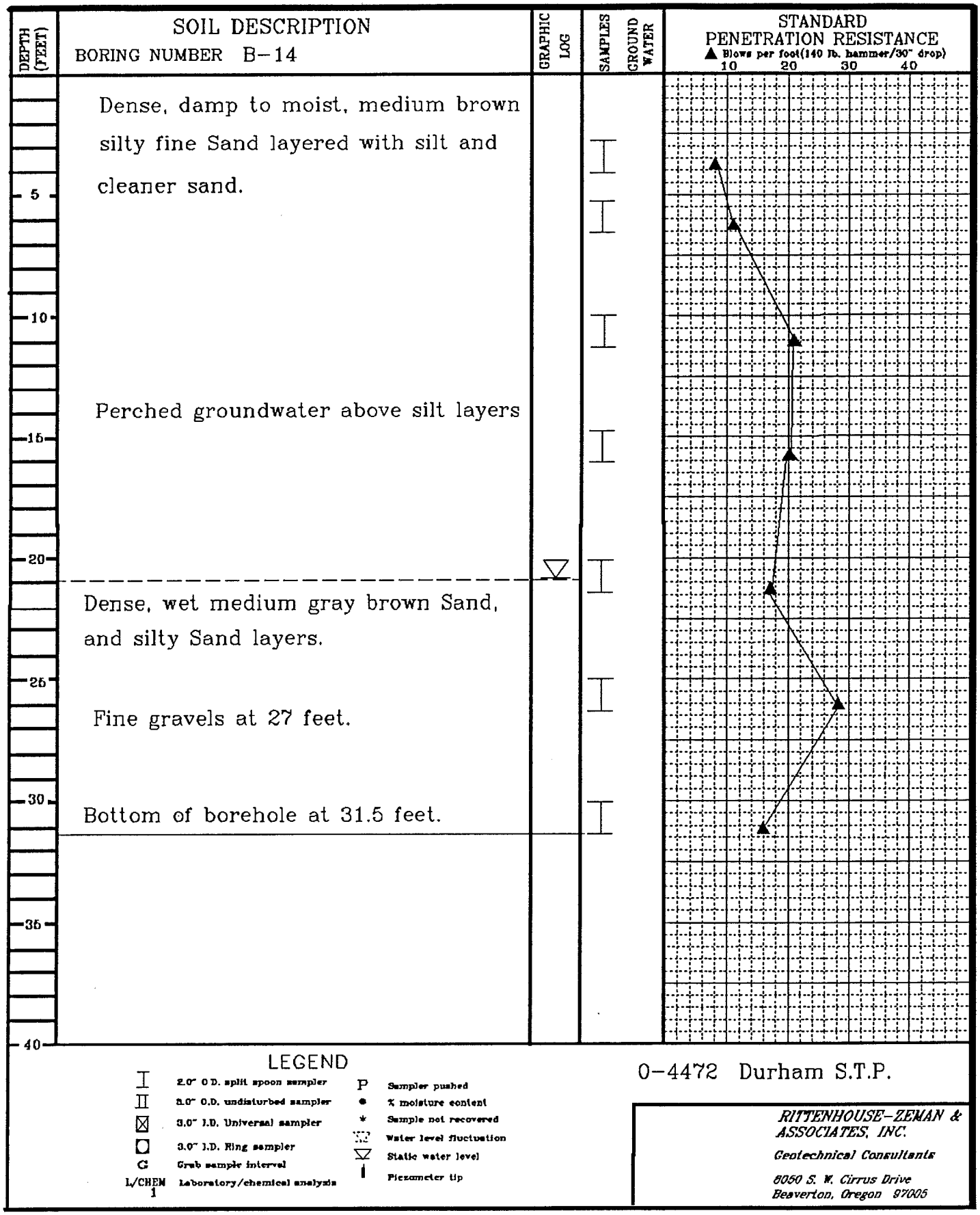
DEPTH (FEET)
SOIL DESCRIPTION
BORING NUMBER B-14
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Dense, damp to moist, medium brown silty fine Sand layered with silt and cleaner sand.
Perched groundwater above silt layers
Dense, wet medium gray brown Sand, and silty Sand layers.
Fine gravels at 27 feet.
Bottom of borehole at 31.5 feet.
5
10
15
20
25
30
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
3.0" I.D. Universal sampler
3.0" I.D. Ring sampler
G Grab sample interval
L/CHEM 1 Laboratory/chemical analysis
P Sampler pushed
% moisture content
* Sample not recovered
Water level fluctuation
Static water level
Piezometer tip
0-4472 Durham S.T.P.
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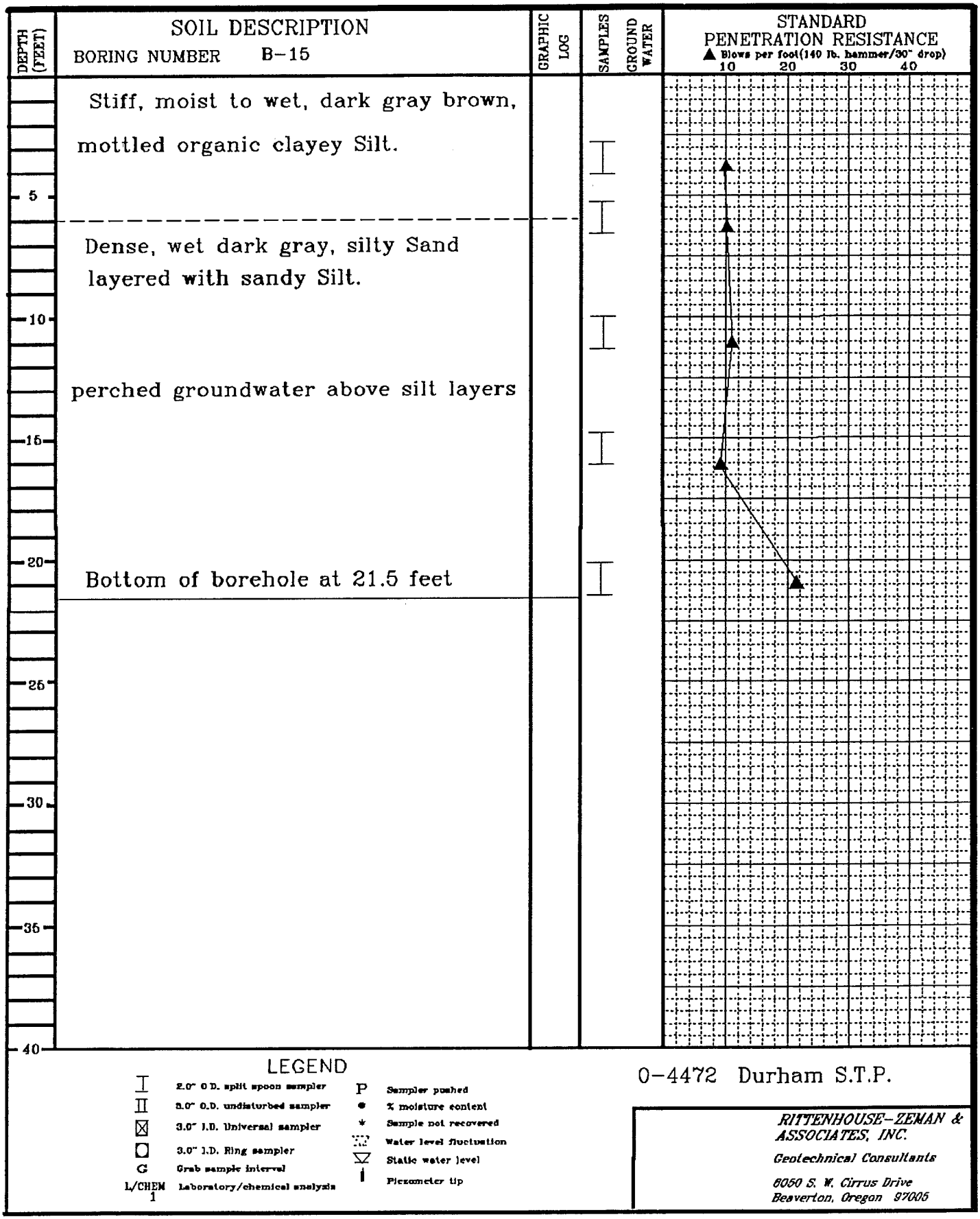

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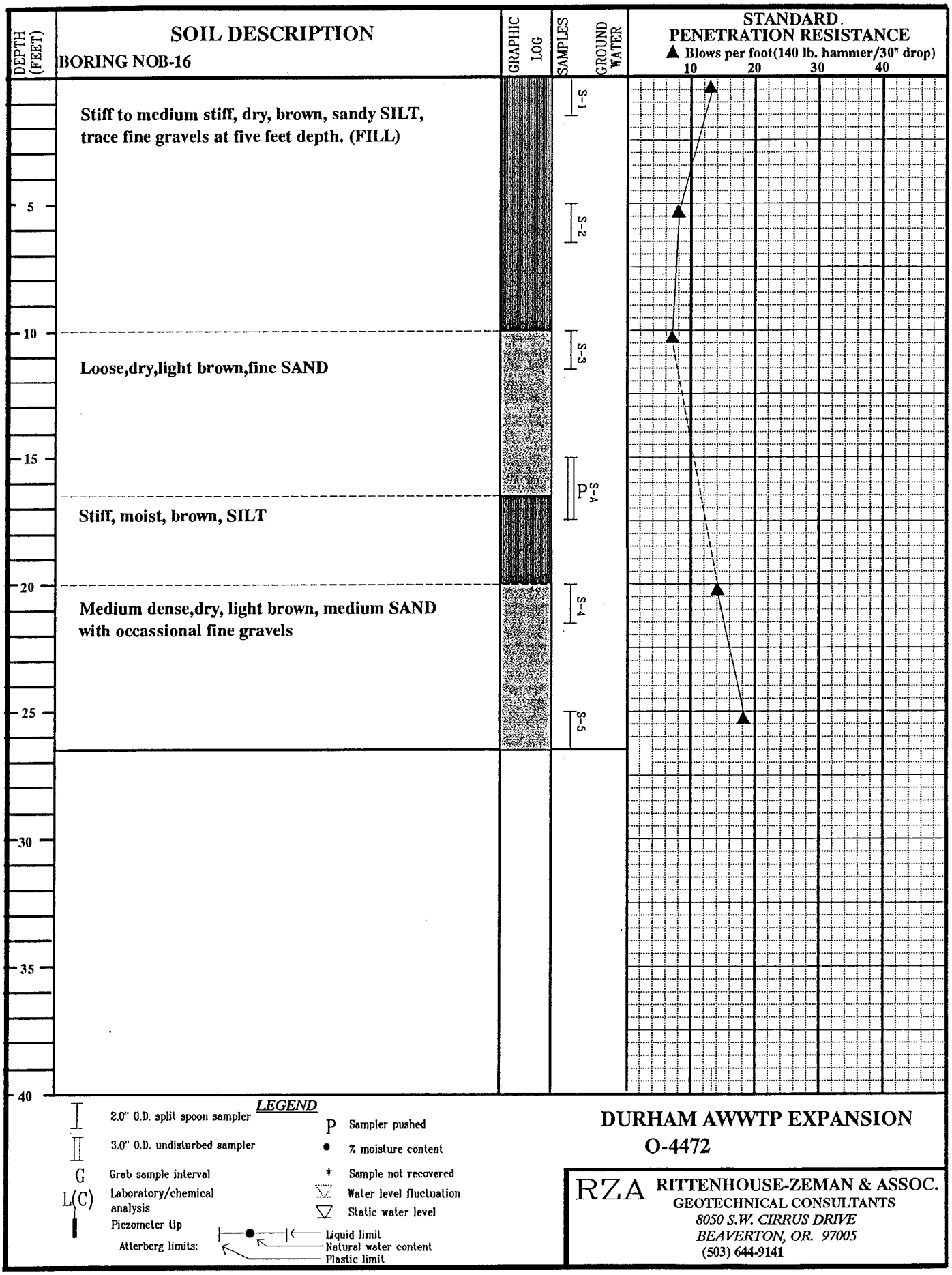

DURHAM AWWTP EXPANSION
O-4472

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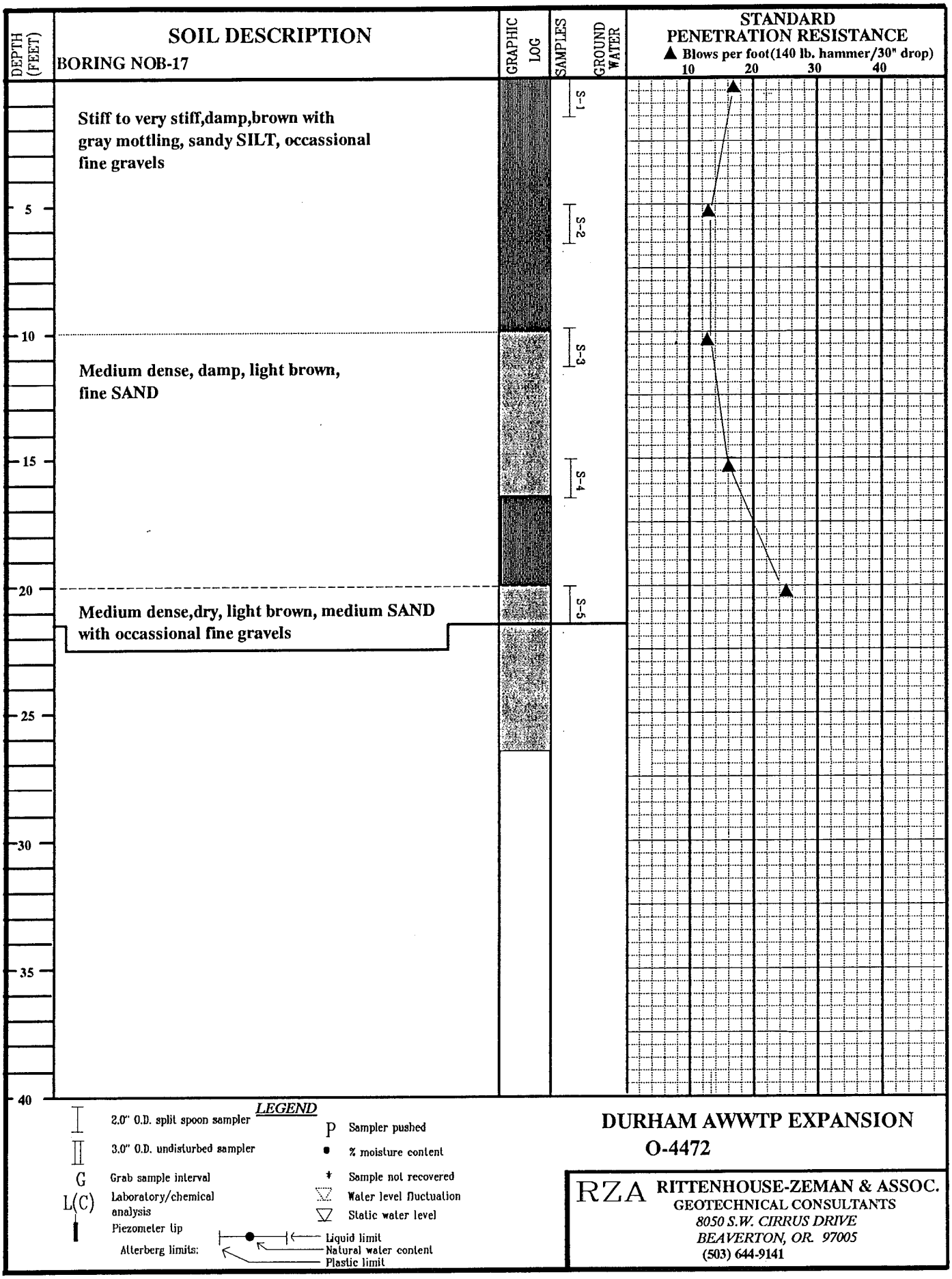
BEAVERTON, OR. 97005
(503) 644-9141


DEPTH (FEET)
SOIL DESCRIPTION
BORING NOB-17
GRAPHIC LOG
SAMPLES
GROUND WATER
STANDARD PENETRATION RESISTANCE
▲ Blows per foot(140 lb. hammer/30" drop)
10
20
30
40
Stiff to very stiff,damp,brown with gray mottling, sandy SILT, occassional fine gravels
Medium dense, damp, light brown, fine SAND
Medium dense,dry, light brown, medium SAND with occassional fine gravels
S-1
S-2
S-3
S-4
S-5
5
10
15
20
25
30
35
40
LEGEND
2.0" O.D. split spoon sampler
3.0" O.D. undisturbed sampler
G Grab sample interval
L(C) Laboratory/chemical analysis
Piezometer tip
Atterberg limits:
P Sampler pushed
% moisture content
Sample not recovered
Water level fluctuation
Static water level
Liquid limit
Natural water content
Plastic limit
DURHAM AWWTP EXPANSION
O-4472
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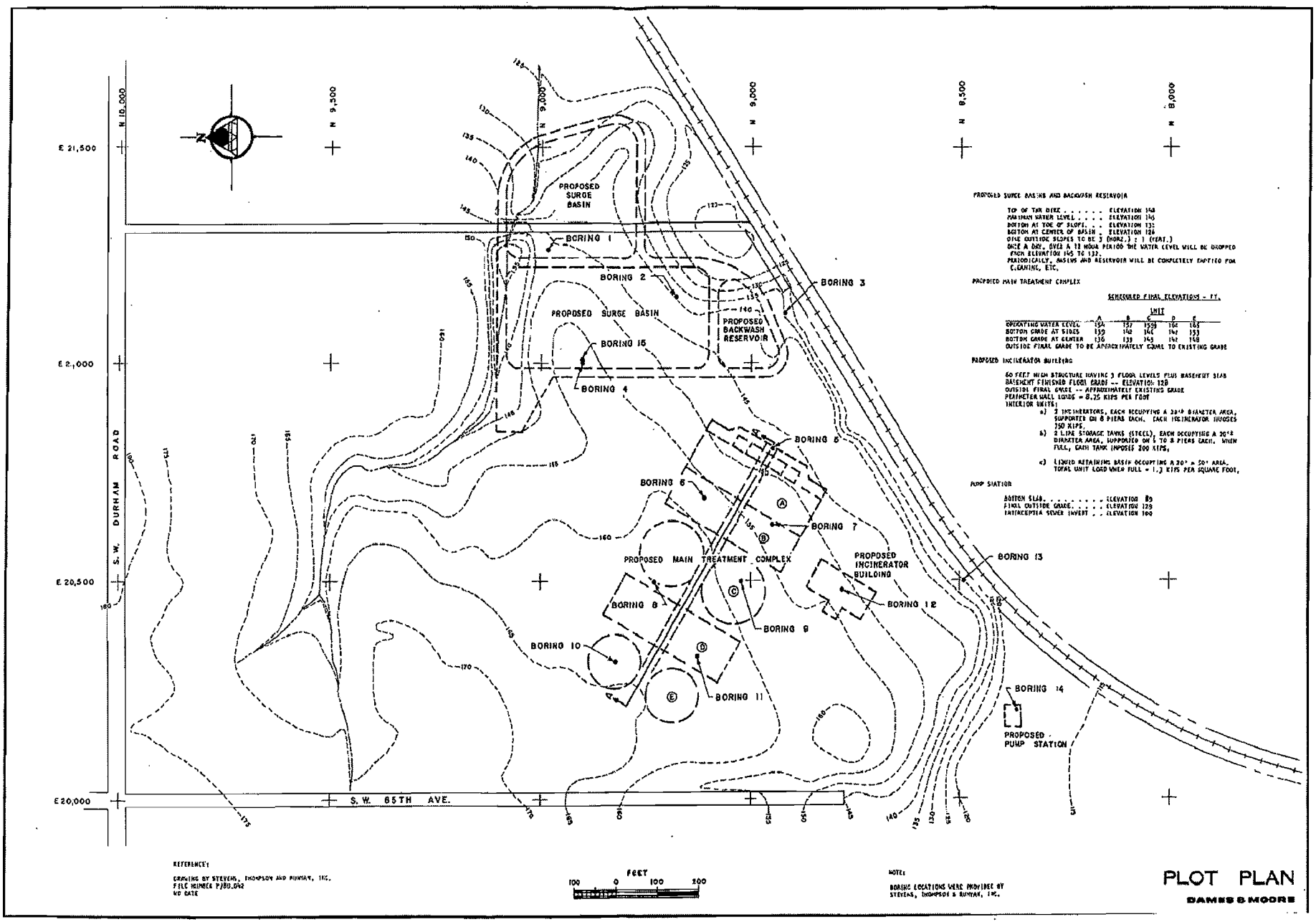
Appendix E.6
Tualatin River Sewage Treatment Project



PLOT PLAN

DAMES & MOORE

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS — MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE.	GRAVEL AND GRAVELLY SOILS — MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS — MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS — MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE.	SILTS AND CLAYS — LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS — LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

NOTES:

1. DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
2. WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

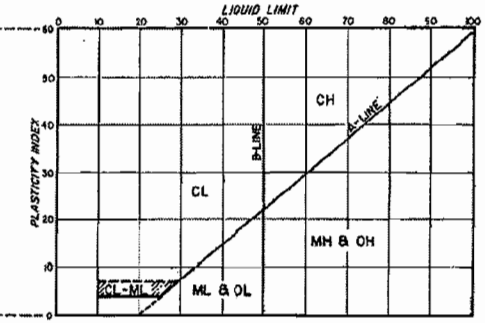
COHESIVE SOILS	(APPROXIMATE SHEARING STRENGTH IN KSF)	COHESIONLESS SOILS	
VERY SOFT	LESS THAN .25	VERY LOOSE	THESE ARE USUALLY BASED ON AN EXAMINATION OF SOIL SAMPLES, PENETRATION RESISTANCE, AND SOIL DENSITY DATA.
SOFT	0.25 TO 0.5	LOOSE	
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	
STIFF	1.0 TO 2.0	DENSE	
VERY STIFF	2.0 TO 4.0	VERY DENSE	
HARD	GREATER THAN 4.0		

GRADATION CHART

MATERIAL SIZE	PARTICLE SIZE — LOWER LIMIT		UPPER LIMIT	
	MILLIMETERS	SIEVE SIZE*	MILLIMETERS	SIEVE SIZE*
SAND				
FINE	.074	#200	0.42	#40
MEDIUM	0.42	#40	2.00	#10
COARSE	2.00	#10	4.76	#4
GRAVEL				
FINE	4.76	#4	19.1	3/4"**
COARSE	19.1	3/4"**	76.2	3"**
COBBLES	76.2	3"**	304.8	12"**
BOULDERS	304.8	12"**	914.4	36"**

*U.S. STANDARD **CLEAR SQUARE OPENINGS

PLASTICITY CHART



SAMPLES

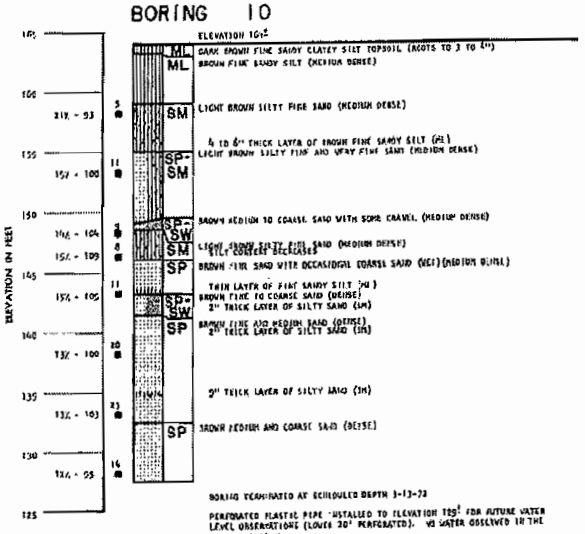
- INDICATES UNDISTURBED SAMPLE
- INDICATES DISTURBED SAMPLE
- INDICATES SAMPLING ATTEMPT WITH NO RECOVERY
- INDICATES LENGTH OF CORING RUN

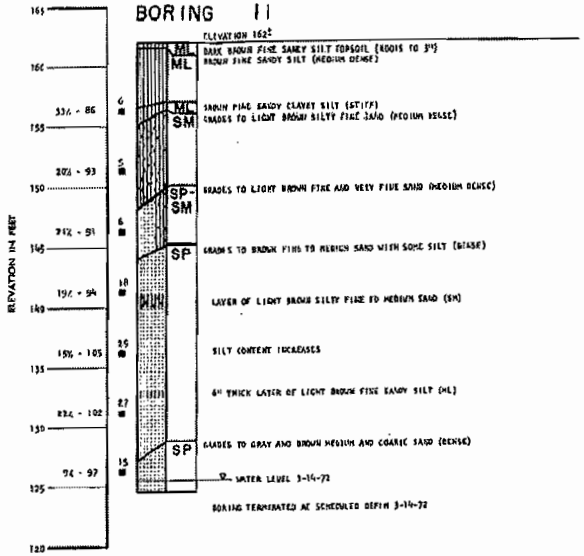
NOTE: DEFINITIONS OF ANY ADDITIONAL DATA REGARDING SAMPLES ARE ENTERED ON THE FIRST LOG ON WHICH THE DATA APPEAR.

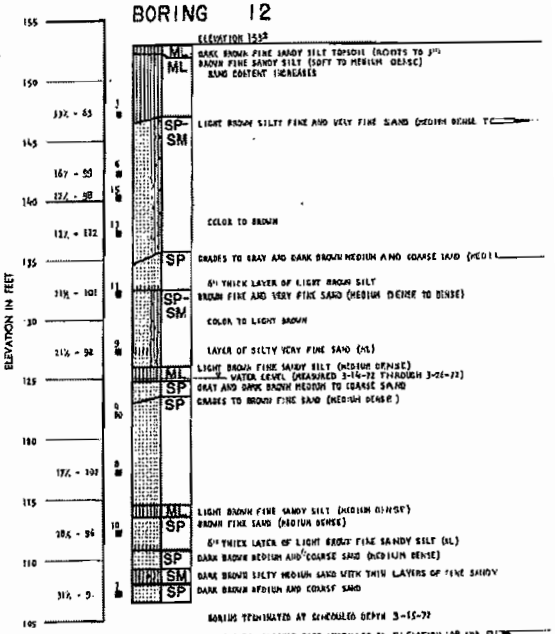
UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE

PLATE A-2







KEY:

■ ← INDICATES UNDISTURBED SAMPLE
■ ← INDICATES DISTURBED SAMPLE

35% - 85 ← FIELD MOISTURE EXPRESSED AS A PERCENT OF THE DRY WEIGHT OF THE SOIL
85 ← IN-SITU DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT

6 ← INDICATES NUMBER OF BLOWS REQUIRED TO DRIVE DAMES & MOORE TYPE-U SAMPLER ONE FOOT WITH 300 POUND WEIGHT FALLING 24 INCHES WHERE NO NUMBER IS SHOWN, SAMPLING INTERFERENCE PREVENTED OBTAINING A RELIABLE COUNT.

NOTES:

1) DISCUSSIONS IN THE TEXT OF THIS REPORT ARE NECESSARY FOR A PROPER UNDERSTANDING OF SUBSURFACE CONDITIONS REVEALED BY THE BORINGS.

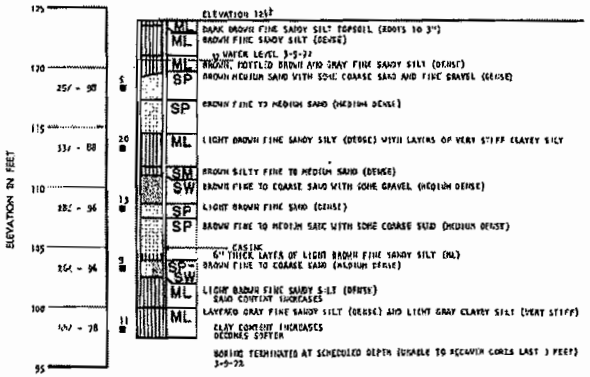
2) THE BORING LOGS DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC BORING LOCATIONS AND ON THE DATES DESIGNATED. SUBSURFACE CONDITIONS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS ENCOUNTERED AT THESE BORING LOCATIONS. ALSO, THE PASSAGE OF TIME MAY RESULT IN A CHANGE OF SUBSURFACE CONDITIONS, IN PARTICULAR GROUND WATER CONDITIONS, AT THESE BORING LOCATIONS.

3) BORING SURFACE ELEVATIONS WERE PROVIDED BY STEVENS, THOMPSON & RUNYAN, INC.

LOG OF BOR

DAMES

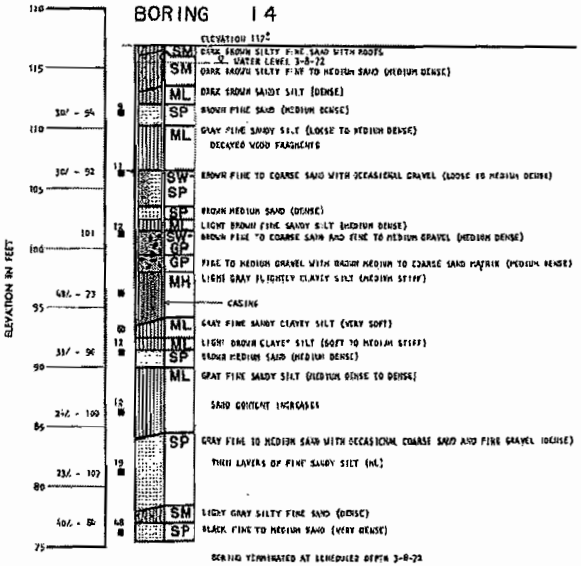
BORING 13



KEY:

- ■ INDICATES UNDISTURBED SAMPLE
- ■ INDICATES DISTURBED SAMPLE
- 35% - 85 — FIELD MOISTURE EXPRESSED AS A PERCENT OF THE DRY WEIGHT OF THE SOIL; IN-SITU DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
- 6 — INDICATES NUMBER OF BLOWS REQUIRED TO DRIVE BARES & MOORE TYPE-L SAMPLER ONE FOOT WITH 300 POUND WEIGHT FALLING 24 INCHES WHERE NO NUMBER IS SHOWN, SAMPLING INTERFERENCE PREVENTED OBTAINING A RELIABLE COUNT.

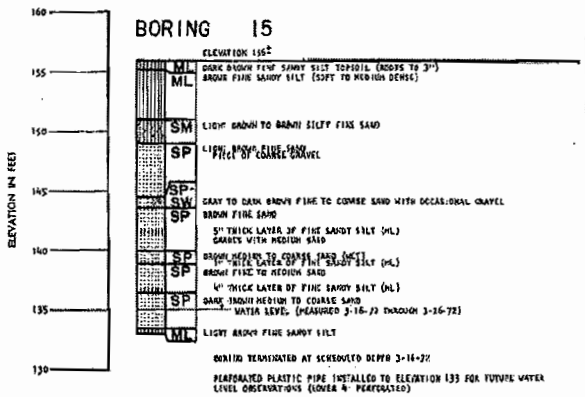
BORING 14



BORING TERMINATED AT SCHEDULED DEPTH 3-8-72

NOTE: WATER OBSERVED FLOWING FROM THE HOLE AT A SMALL RATE ON 3-12 & 3-15-72

BORING 15



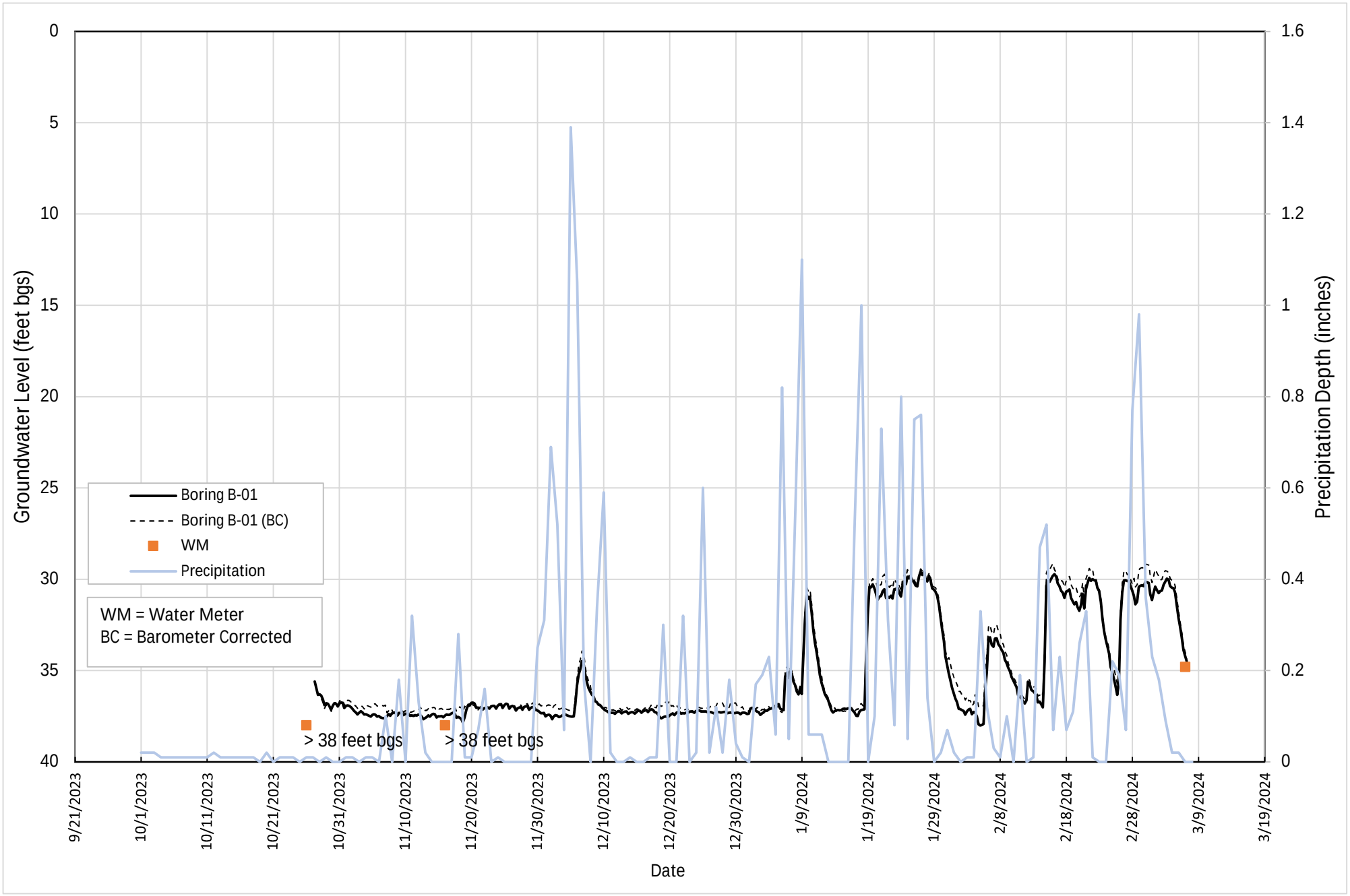
NOTES:

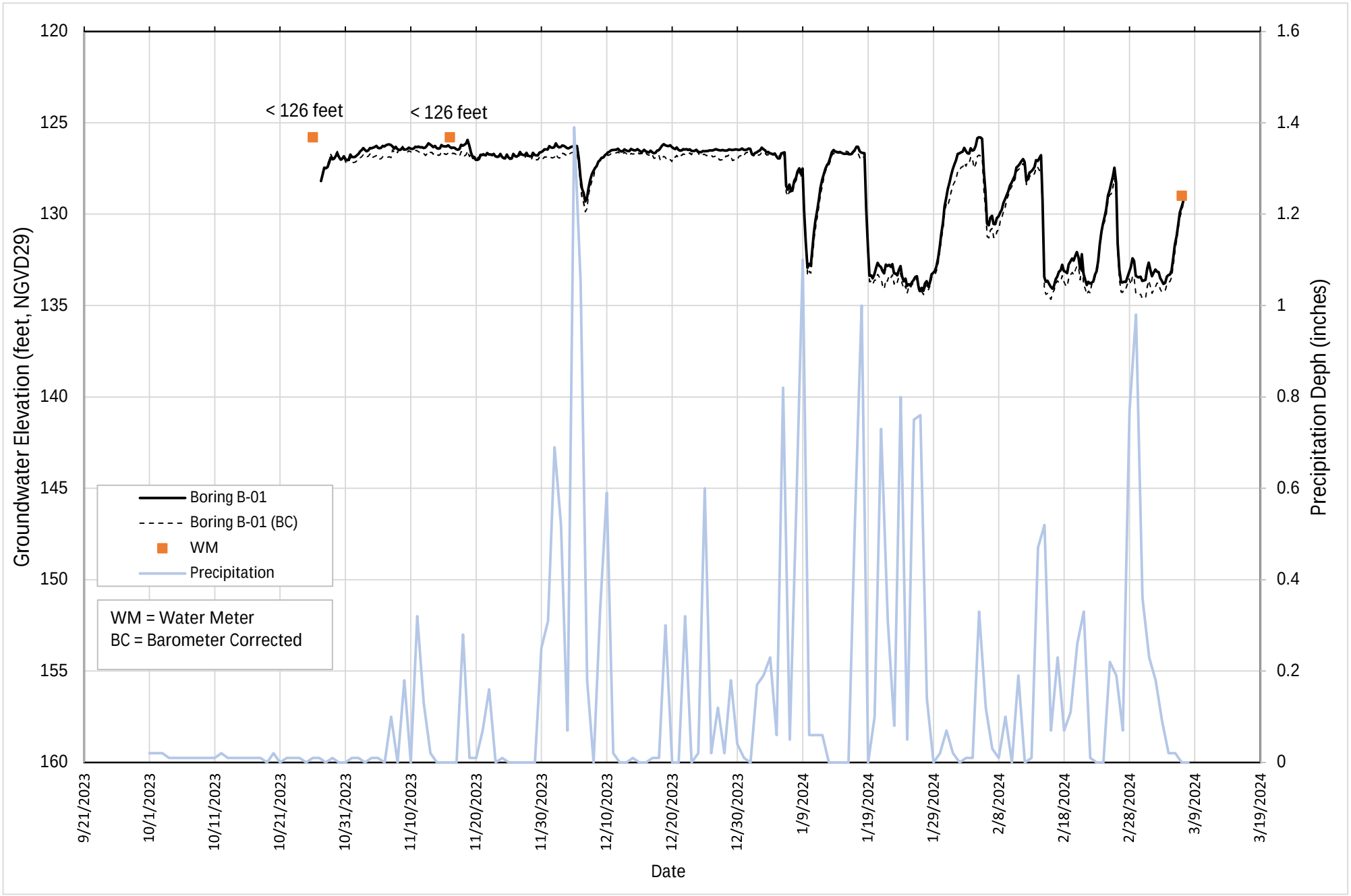
1) DISCUSSIONS IN THE TEXT OF THIS REPORT ARE NECESSARY FOR A PROPER UNDERSTANDING OF SUBSURFACE CONDITIONS REVEALED BY THE BORINGS.
2) THE BORING LOGS DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC BORING LOCATIONS AND ON THE DATES DESIGNATED. SUBSURFACE CONDITIONS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS ENCOUNTERED AT THESE BORING LOCATIONS. ALSO, THE PASSAGE OF TIME MAY RESULT IN A CHANGE OF SUBSURFACE CONDITIONS, IN PARTICULAR GROUND WATER CONDITIONS, AT THESE BORING LOCATIONS.
3) BORING SURFACE ELEVATIONS WERE PROVIDED BY STEVENS, THOMPSON & RUNYAN, INC.

LOG OF BORINGS

DAMES & MOORE

Appendix F
Groundwater Data


Groundwater Level (feet bgs)
Precipitation Depth (inches)
Date
0
5
10
15
20
25
30
35
40
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
9/21/2023
10/1/2023
10/11/2023
10/21/2023
10/31/2023
11/10/2023
11/20/2023
11/30/2023
12/10/2023
12/20/2023
12/30/2023
1/9/2024
1/19/2024
1/29/2024
2/8/2024
2/18/2024
2/28/2024
3/9/2024
3/19/2024
Boring B-01
Boring B-01 (BC)
WM
Precipitation
WM = Water Meter
BC = Barometer Corrected
> 38 feet bgs
> 38 feet bgs


120
125
130
135
140
145
150
155
160
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
< 126 feet
< 126 feet
Groundwater Elevation (feet, NGVD29)
Precipitation Deph (inches)
Boring B-01
Boring B-01 (BC)
WM
Precipitation
WM = Water Meter
BC = Barometer Corrected
9/21/2023
10/1/2023
10/11/2023
10/21/2023
10/31/2023
11/10/2023
11/20/2023
11/30/2023
12/10/2023
12/20/2023
12/30/2023
1/9/2024
1/19/2024
1/29/2024
2/8/2024
2/18/2024
2/28/2024
3/9/2024
3/19/2024
Date

SECTION 02315
EXCAVATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation Plan, Detailing:
   a. Anticipated difficulties and proposed resolutions.
   b. Methods and sequencing of excavation.
   c. Numbers, types, and sizes of equipment proposed to perform excavations.
   d. Proposed locations of stockpiled excavated material.
   e. Proposed onsite and offsite spoil disposal sites.

B. Trenchless Installation Submittal:

1. If excavation using trenchless installation methods, such as auger boring, pipe jacking, or hand mining, are used to install utilities, provide the following:
   a. Provide casing installation schedules which include schedules of excavation, pipeline installation, and backfill operations.
   b. Provide detailed plans of the methods and procedures to be utilized to complete the Work. Include descriptions of trenchless construction operations.
   c. Provide details of the tunneling equipment including dimensions, weight, power and torque capabilities, rotational capabilities, and configuration of cutterhead, as applicable.
   d. Provide the qualifications of the Contractor, superintendent, and operator responsible for constructing the trenchless installation who will perform the trenchless construction work and lead engineer responsible for support calculations. Include a list of past trenchless construction projects during the past 5 years showing: Date of work, location, project name, owner, ground conditions, and trenchless methods utilized.
   e. Submit names and training qualifications of the Site Safety representative personnel and personnel that will perform air quality monitoring.
   f. Spoils handling operations plan including mucking systems and muck handling and transportation equipment.

g. Trenchless Plan shall be submitted not less than 30 days before any work relating to the trenchless operation is commenced. No excavation for trenchless operations shall be undertaken until receipt of the Owner's written acceptance of the plan.
h. Working Drawings: The Contractor shall submit working drawings for all fabricated materials, casing pipe dimensions, wall thickness, location of grout ports, grout port and plug details.

1.02 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.03 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.04 SEQUENCING AND SCHEDULING

A. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 02200, Site Clearing, prior to excavating.

B. Dewatering: Conform to applicable requirements of Section 02240, Dewatering, prior to initiating excavation.

C. Excavation Support: Install and maintain, as specified in Section 02260, Shoring, and Section 02265, Secant Pile Excavation Support System, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Use of explosives is not allowed.

D. Remove or protect obstructions as shown and as specified in Section 01500, Temporary Facilities and Controls.

3.02 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width: 18 inches or as shown.
   b. 4-Inch to Less Than or Equal to 18-Inch Outside Diameter or Width: 24 inches greater than outside diameter or width of pipe, conduit, or duct bank.
   c. Greater Than 18-inch Outside Diameter or Width: 36 inches greater than outside diameter or width of pipe, conduit, or duct bank.
2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between or as shown.
3. Increase trench widths by thicknesses of sheeting.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work. Pipe of greater strength or superior pipe bedding, when approved in writing by Engineer, may be used in lieu of maintaining the trench widths shown or specified.

3.04 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove loose stones and rock that exceed 3-inch diameter. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

D. Install soil stabilization and erosion protection measures as specified in Section 02370, Soil Stabilization, immediately upon completion of embankments or cut slopes.

3.05 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could cause damage by structural failure or settlement.

3.06 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.

B. Dispose of debris resulting from removal of underground facilities as specified in Section 02220, Demolition, for demolition debris.

END OF SECTION

SECTION 02316
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-lbf/feet^3 (2,700 kN-m/m^3)).
   e. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   f. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   g. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   h. D5268, Standard Specification for Topsoil Used for Landscaping and Construction Purposes.

1.02 DEFINITIONS

A. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

B. Completed Course: A course or layer that is ready for next layer or next phase of Work.

C. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

D. Geosynthetics: Geotextiles, geogrids, or geomembranes.

E. Imported Material: Materials obtained from sources offsite, suitable for specified use.

F. Influence Area:

1. Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
   a. 1-foot outside outermost edge at base of foundations or slabs.
   b. 1-foot outside outermost edge at surface of roadways or shoulder.
   c. 0.5-foot outside exterior at spring line of pipes or culverts.

G. Lift: Loose (uncompacted) layer of material.

H. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

I. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

J. Proof-Rolling: Test rolling of subgrade by heavily load vehicle or roller to identify areas that will not support the future loading without excessive settlement or rutting.

K. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

L. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

M. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.

N. Standard Specifications: When referenced in this section, shall mean Oregon Standard Specifications for Construction, 2021.

O. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

P. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Gradation test results for imported materials.

B. Informational Submittals:

1. Certified test results from independent testing agency.
2. Manufacturer’s data sheets for compaction equipment.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure or tank is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from these Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in; Section 02200, Site Clearing; Section 02315, Excavation; and Section 02319, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03300, Cast-in-Place Concrete. Obtain Engineer’s acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03300, Cast-in-Place Concrete.

D. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 02319, Subgrade Preparation.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Gradation Tests:

1. As necessary to locate acceptable sources of imported material.
2. During production of imported material, test minimum one per each material.

2.02 SELECT EARTHFILL

A. Excavated material from required excavations free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials, with less than 15 percent fine content.

B. Class D backfill material conforming the requirements in Section 00405.14, Trench Backfill, of the Standard Specifications.

C. Provide imported material of equivalent quality, if required to accomplish Work.

2.03 GRANULAR FILL

A. 1-inch minus or 3/4-inch minus crushed gravel or crushed rock.

B. Free from dirt, clay balls, and organic material.

C. Well-graded from coarse to fine conforming the requirements in Section 02630, Base Aggregate, of Standard Specifications.

2.04 GRANULAR DRAIN MATERIAL

A. 1-inch minus crushed gravel or crushed rock free from foreign materials; rounded rock is not acceptable.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

Sieve Size	Percent Passing by Weight
1-inch	100
3/4-inch	80-100
3/8-inch	5-20
1/4-inch	0-10
No. 4	0-4
No. 200	<2

2.05 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.06 BASE COURSE ROCK

A. As specified in Section 02710, Aggregate Base Courses.

2.07 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2-inch particle size.

2.08 SOIL COVER OVER GEOTEXTILES

A. Particle Size: Maximum 1-inch.

B. Free of sharp angular pieces that may damage geotextile.

2.09 TOPSOIL

A. Imported, meeting ASTM D 5268; natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles, conforming to USDA classification for Loam or Sandy Loam; friable, pervious, and black or a darker shade of brown, 100 percent passing through a 1/2-inch screen, containing no weeds, roots or deleterious material, and containing not more than 2 percent foreign materials on a dry weight basis and complying with the following physical properties.

B. Texture: A loam.

C. Organic Matter: 2 percent minimum, 5 percent maximum on a dry weight basis.

D. Sodium Adsorption Ratio (SAR): Less than 6.0.

E. Saturation Extract Concentration for Boron: less than 1.0

F. pH range of from 5.0 to 7.5.

G. Maximum Estimated Saturated Paste Electrical Conductivity: Less than 3m.mhos/cm (dS/m).

H. Non-Soil Components: Less than 2 percent by dry weight basis.

I. Markers for Hazardous Materials: None or pass.

J. Minimal weed seed.

K. If regenerative noxious weeds (including, but not limited to, quack grass, nutsedge grass, and horsetail) are present in the soil, all resultant growth including roots shall be removed throughout 1-year period after acceptance of work at no additional cost to Owner.

2.10 COMPOST

A. Commercially produced garden mulch made from composted yard debris and amended with a minimum of two of the following components:

1. Sand, loam, mushroom compost, composted manure, rotted sawdust.

B. Mulch shall be free from noxious weed seed, trash, plastics, and all chemicals or materials harmful to plant life.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable, as specified in Section 02320, Trench Backfill.
4. Install item.
5. Backfill envelope zone and remaining trench, as specified in Section 02320, Trench Backfill, before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 8-inch maximum thickness and compact each lift to minimum of 94 percent relative compaction as determined in accordance with ASTM D1557 Method.

B. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 8-inch maximum thickness and compact each lift to minimum of 94 percent relative density.

C. Around Structures: Backfill with granular fill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 8-inch maximum thickness and compact each lift to minimum 94 percent relative compaction as determined in accordance with ASTM D1557 Method.

3.03 FILL

A. Outside Influence Areas beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities:

1. Unless otherwise shown, place Select Earthfill as follows:
   a. Allow for 12-inch thickness of topsoil where required.
   b. Maximum 8-inch thick lifts.
   c. Place and compact fill across full width of embankment.
   d. Compact to minimum 94 percent relative compaction as determined in accordance with ASTM D1557.
   e. For material with more than 30 percent retained on 3/4-inch sieve, compaction verification should consist of proof-rolling every second lift in the presence of Engineer. Perform proof-roll using loaded dump truck or similar heavy-wheeled vehicle to detect soft or loose subgrade or unsuitable material, as determined by Engineer.
   f. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.04 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from these Specifications.

2. If test results indicate material does not meet specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet specification requirements.

B. In-Place Density Tests:

1. In accordance with ASTM D6938. During placement of materials, test as follows:
   a. Granular Fill Beneath Digester Foundation: Minimum four tests, with a minimum of one in each quadrant.
   b. Granular Fill Around Digester: Two tests every 8-inch lift for the first three lifts, and two tests for every 2 feet of vertical fill placement, thereafter, evenly distributed around the digester.
   c. Sand: Four tests every 2 feet of vertical fill placement, evenly distributed across the Site.
   d. Base Course Rock: One test every 200 linear feet of roadway per lift.
   e. Select Earthfill: Minimum two tests per day.
   f. Perform additional testing if failing tests occur and/if variable conditions are encountered.

3.05 GRANULAR BASE

A. Place and Compact as specified in Section 02710, Aggregate Base Courses.

3.06 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows:

1. Beneath Footings: Granular fill.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Granular fill.
4. Trenches:
   a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 02320, Trench Backfill.
   b. Authorized Overexcavation: Trench stabilization material, as specified in Section 02320, Trench Backfill.

5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
    a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Select Earthfill.
    b. Steep Slopes (Steeper than 3:1):
        1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
        2) Backfilling overexcavated areas is prohibited, unless in Engineer's opinion, backfill will remain stable, and overexcavated material is replaced as compacted select earthfill.

3.07 PLACING FILL OVER GEOSYNTHETICS

A. General:

1. Place fill over geosynthetics with sufficient care so as not to damage them.
2. Place fill only by back dumping and spreading only.
3. Dump fill only on previously placed fill.
4. While operating equipment, avoid sharp turns, sudden starts or stops that could damage geosynthetics.

B. Hauling: Operate hauling equipment on minimum of 3 feet of covering.

C. Spreading:

1. Spreading equipment shall be track mounted, low ground pressure, D-6 or lighter.
2. Operate spreading equipment on minimum of 12 inches of fill over geosynthetics.
3. Spread fill in same direction as unseamed overlaps to avoid separation of seams and joints.
4. Never push fill downslope. Spread fill over sideslopes by pushing up from slope bottom.
5. Flatten wrinkles of geotextiles in direction of spreading.
6. Maintain proper overlap of unseamed geosynthetics.
7. Avoid overstressing geosynthetics and seams.

D. Compaction: Compact fill only after uniformly spread to full thickness shown.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to geosynthetics, so repairs may be made.
2. Clear overlying fill as necessary to repair damage.
3. Repairs to geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.

3.08 TOPSOIL PLACEMENT

A. Provide minimum 12-inch thick topsoil course over all disturbed areas restored with seeding and planting.

B. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

C. Place one-half of the total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer. Place remainder of topsoil to depth of 6 inches where seeding and planting are scheduled.

D. Uniformly distribute to within 1/2-inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove stones exceeding 1-1/2-inch diameter, roots, sticks, debris, and foreign matter during and after topsoil placement.

F. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

3.09 COMPOST

A. Application Rate: 2-inch depth.

END OF SECTION

SECTION 02319
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-lbf/feet^3 (2,700 kN-m/m^3)).

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 02316, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, dewatering, excavation to grade, and scarification and compaction of subgrade.

A. Proof-Rolling: Test rolling of subgrade by heavily load vehicle or roller to identify areas that will not support the future loading without excessive settlement or rutting.

B. Relative Compaction: As defined in Section 02316, Fill and Backfill.

C. Relative Density: As defined in Section 02316, Fill and Backfill.

D. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

E. Unsuitable Material: Subgrade material unsuitable for the project consisting of rubble, debris, vegetation, and undocumented fill.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02220, Demolition; Section 02200, Site Clearing; Section 02240, Dewatering; and Section 02315, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Owner's Representative when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow as specified in Section 02315, Excavation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

A. Under Select Earthfill: Scarify and compact upper 8 inches to minimum of 90 percent relative compaction as determined in accordance with ASTM D1557 Method.

B. Under Pavement Structures, Building Foundations: Compact the upper 12 inches to minimum of 94 percent relative compaction as determined in accordance with ASTM D1557 Method.

C. Subgrade rutting or pumping during compaction because of excessive water buildup, indicate that groundwater dewatering efforts or moisture conditioning efforts are ineffective. Discontinue compaction until requirements specified in Section 02240, Dewatering, are met.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 TESTING

A. In-place density test in accordance with ASTM D6938.

1. Beneath the Digester Foundation: one test every 500 square feet.
2. Other Areas: one test every 1,000 square feet.

3.05 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact.
2. Overexcavate as specified in Section 02315, Excavation, and replace with suitable material from the excavation, as specified in Section 02316, Fill and Backfill.

B. Unsuitable Material: Overexcavate as specified in Section 02315, Excavation, and replace with suitable material from the excavation, as specified in Section 02316, Fill and Backfill.

END OF SECTION

SECTION 02320
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
   h. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   i. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 feet-lbf/feet^3 (2,700 kN-m/m^3)).
   j. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   k. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   l. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   m. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   n. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: As defined in Section 02316, Fill and Backfill.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.

J. Well-Graded:

1. A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:
   a. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
   b. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer's descriptive literature for marking tapes and tracer wire.
2. CLSM Pipe Embedment Plan:
   a. Includes at a minimum:
      1) Design assumptions and calculations to prevent uplift (flotation) or lateral deformation of pipes and structures.
      2) Methods and sequence of CLSM placement.
      3) Methods to prevent movement or deformation of pipes and structures.

B. Informational Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.
2. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.
3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 PRODUCTS

2.01 GEOTEXTILE

A. As specified in Section 02371, Geotextile.

2.02 MARKING TAPE

A. Nondetectable:

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 4 mils.
3. Width: 3 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
   a. Reef Industries; Terra Tape.
   b. Mutual Industries; Non-detectable Tape.
   c. Presco; Non-detectable Tape.

B. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 3 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.

C. Color: In accordance with APWA Uniform Color Code.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.03 TRACER WIRE

A. Material: Minimum 10-gauge solid copper or copper jacket with a steel core, with high-density polyethylene (HDPE) or high-molecular weight polyethylene (HMWPE) insulation suitable for direct bury.

B. Splices: Use wire nut or lug suitable for direct burial as recommended by tracer wire manufacturer.

C. Manufacturers:

1. Copperhead Industries, LLC.
2. Performance Wire & Cable Inc.
3. Pro-line Safety Products Company.

D. Color: In accordance with APWA Uniform Color Code per table above.

2.04 TRENCH STABILIZATION MATERIAL

A. As specified for foundation stabilization rock in Section 02316, Fill and Backfill.

2.05 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.

1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
3. Pipe Under 18-Inch Diameter: 3/4-inch maximum particle size, except 1/4-inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3-inch diameter.
4. Pipe 18-Inch Diameter and Greater: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe.
5. Perforated Pipe: Granular drain material.
6. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.06 SELECT EARTHFILL

A. As specified in Section 02316, Fill and Backfill.

2.07 GRANULAR FILL

A. As specified in Section 02316, Fill and Backfill.

2.08 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. Select and proportion ingredients to obtain compressive strength between 50 pounds per square inch and 150 pounds per square inch at 28 days in accordance with ASTM D4832.

B. Materials:

1. Cement: ASTM C150/C150M, Type I or Type II.
2. Aggregate: ASTM C33/C33M, Size 7.
3. Fly Ash (Pozzolan):
    a. Class F fly ash in accordance with ASTM C618, except as modified herein:
        1) ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.09 CONCRETE BACKFILL

A. Provide as specified in Section 03300, Cast-in-Place Concrete.

2.10 TOPSOIL

A. As specified in Section 02316, Fill and Backfill.

2.11 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:

1. Earth backfill, including specified class.
2. Trench stabilization material.
3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:

1. Controlled low strength material.
2. Concrete.

PART 3 EXECUTION

3.01 TRENCH PREPARATION

A. Water Control:

1. As specified in Section 02240, Dewatering.
2. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.
3. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
4. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required.

3.03 GEOTEXTILE INSTALLATION

A. Where shown and as specified in Section 02371, Geotextile, except as follows:

1. Extend geotextile for full width of trench bottom and up the trench wall to the top of the pipe zone, or base material for manholes and miscellaneous structures.
2. Anchor geotextile trench walls prior to placing trench stabilization or bedding material.
3. Provide 24-inch minimum overlap at joints.

3.04 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.05 BEDDING

A. Furnish imported bedding material.

B. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum thickness as follows:

1. Pipe 15 Inches and Smaller: 4 inches.
2. Conduit: 3 inches.
3. Direct-Buried Cable: 3 inches.
4. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1-inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.06 PIPE ZONE BACKFILL

A. Upper limit of pipe zone shall not be less than following:

1. Pipe: 12 inches, unless shown otherwise.
2. Conduit: 3 inches, unless shown otherwise.
3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 3 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2-pipe diameter.
2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.

E. Mechanically compact each lift to a minimum of 93 percent relative compaction in accordance with ASTM D1557 prior to placing succeeding lifts.

F. Do not use power-driven impact compactors to compact pipe zone material.

3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, at depth shown on the Drawings. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
2. Nondetectable Marking Tape: Install with metallic piping.

3.08 TRACER WIRE INSTALLATION AND TESTING

A. Install tracer wire continuously along centerline of nonmetallic buried piping.

B. Attach wire to top of pipe using tape at maximum of 10-foot intervals. In areas where depth of cover is excessive for allowing detection of tracer wire with electronic pipe locator, install tracer wire within pipe backfill directly above pipe centerline at a minimum depth of 3 feet.

C. Install splices in accordance with manufacturer’s instructions for direct bury applications. Tie ends of wire to be joined in a knot as required to reduce tension on splice.

D. Bring tracer wire to surface at each valve box, curb box, vault, air valve, blowoff valve, hydrant, and pipeline marker. Tracer wire shall be brought to surface at least every 1,000 feet. If distance between pipe appurtenances exceeds 1,000 feet, install valve box to allow access to tracer wire. Mark valve box cover with the word “TRACER.” Coil enough excess tracer wire at each appurtenance to extend wire 12 inches above ground.

E. Test continuity of tracer wire using electronic pipe locator in presence of Engineer prior to paving.

3.09 BACKFILL ABOVE PIPE ZONE

A. General:

1. Process excavated material to meet specified gradation requirements for Select Earthfill, where use is allowed.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.

B. Granular Fill:

1. Place in areas beneath pavement or gravel surfaces.
2. Place in lifts not exceeding thickness of 8 inches.
3. Mechanically compact each lift to a minimum of 93 percent relative compaction in accordance with ASTM D1557 prior to placing succeeding lifts.

C. Select Earthfill:

1. Place in landscape areas outside of pavements or gravel surfacing.
2. Backfill trench above pipe zone with Select Earthfill to a depth of 12 inches below original ground surface.
3. Mechanically compact each lift to a minimum of 90 percent relative compaction as determined in accordance with ASTM D1557 Method prior to placing succeeding lifts.
4. Fill remainder of trench with topsoil over entire trench width.

D. Controlled Low Strength Material:

1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
3. In other areas fill trench section as shown.

3.10 TESTING

A. Pipe Zone Material: Minimum one test for each lift per 200 linear feet of trench.

B. Backfill above Pipe Zone Material: Minimum one test for each lift per 200 linear feet of trench.

3.11 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 12 inches of backfilled trench. Contractor to provide 2 inches of compost on top of topsoil in non-hardscaped areas.

B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.12 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.

D. Concrete Pavement: Replace settled slabs as specified in Section 02772, Asphalt Paving.

E. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 02772, Asphalt Paving.

F. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.13 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION

SECTION 02370
SOIL STABILIZATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Official Seed Analysts of North America.

1.02 THE REQUIREMENT

A. The Contractor shall provide erosion control barriers, complete and in place, in accordance with the Contract Documents, the 1200-CN permit requirements, and Chapter 6 of Clean Water Services' Design and Construction Standards (June 2007).

B. The Contractor shall provide erosion protection including fertilizing, seeding, and mulching for all disturbed areas, including stockpiled berms in accordance with the Contract Documents.

1.03 CONTRACT DOCUMENT SUBMITTALS

A. Upon completion of all excavation, backfill, structural fill, site improvements, drainage, and landscaping work, the Contractor shall submit Notice of Termination Application for NPDES General Permit to Discharge Storm Water Associated with Construction Activity to DEQ Northwest Region, 2020 S.W. 4th Avenue, Suite 400, Portland, Oregon 97201-4987.

B. Submittals shall be in accordance with Section 01330, Submittal Procedures.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Fertilizer shall be 39 – 0 – 0 (with 5 percent to 8 percent sulfur).

2.02 SEED

A. Provide the following seed mixture for all disturbed areas except in areas designated Agricultural Lands on the Drawings, or areas otherwise noted on the Drawings or in the Specifications for restoration.

Kind of Seed	Weight Percentage
Elka Dwarf Perennial Rye Grass	70 percent
Creeping Red Fescue	20 percent
Kentucky Blue Grass	10 percent

B. General:

1. Seeds shall be labeled in accordance with USDA Rules and Regulations under the Federal Seed Act.
2. Seed that is wet or moldy or has been damaged in transit will not be accepted.

2.03 MULCH

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, clean "fieldstraw" from Deschampsia caespitosa.

B. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

C. Special Seeding and Mulching Equipment: Hydraulic equipment used for the application of fertilizer, seed and slurry of prepared wood-cellulose fiber shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend and homogeneously mix the slurry specified. The slurry distribution lines shall be large enough to prevent stoppage. The discharge line shall be equipped with a set of spray nozzles that will provide even distribution of the slurry on the various slopes.

2.04 EROSION CONTROL MATTING

A. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.

B. Manufacturer and Product: North American Green, Evansville, IN; SC150BN blanket.

2.05 REINFORCED PLASTIC COVERING

A. Physical Requirement (Minimum Average Roll Values):

1. Tear Strength: 130 pounds.
2. Elongation: 620 percent.
3. Minimum Thickness: 6 mil.

B. Manufacturers:

1. Reed Industries, Inc., Houston, TX.
2. Griffolyn Co., Houston, TX.

2.06 SOIL TACKIFIER

A. Soil tackifier shall be Cliffhanger Tack (Quattro Environmental, Inc.), EcoFibre and Tac (Canfor), “or-equal.”

2.07 SEDIMENT FENCE

A. Support Posts: As recommended by manufacturer of geotextile.

B. Fasteners: Heavy-duty wire staples at least 1-inch long, tie wires, or hog rings, as recommended by manufacturer of geotextile.

C. Filter Fabric: Polyester, polypropylene, or nylon filaments, woven into a uniform pattern, distinct and measurable openings.

1. Filaments: Resistant to damage from exposure to ultraviolet rays and heat.
2. Material Edges: Finish so that filaments retain their relative positions under stress.

D. In accordance with requirement of Table No. 1:

Table No. 1 Filter Fabric		
Physical Property	**Required Value**	**Test Method**
Apparent Opening Size, max.	30	U.S. Standard Sieve
Grab Tensile Strength, lb., min. ARV	90	ASTM D4632
Elongation, percent max.	25	ASTM D4632
Ultraviolet Stability Retained Strength, percent	70	ASTM D4355
Permittivity, min, ARV	0.05	ASTM D4491

E. Manufacturers:

1. Polyfelt, Evergreen, AL.
2. Dupont Co., Wilmington, DE.
3. Mirafi, Inc., Charlotte, NC.

2.08 DUST CONTROLLER

A. Nontoxic materials that do not have an adverse effect on soil structure or establishment and growth of vegetation.

2.09 CONSTRUCTION FENCE

A. Ultraviolet stabilized polyethylene or polypropylene safety fence, 4 feet in height, and yellow or orange in color.

2.10 BIOFILTER BAGS

A. Bags: Made of burlap, jute, geotextile, or other pervious material capable of holding contents while allowing water to pass through bag. Bags shall have minimum dimensions of 2 feet long by 1-foot high by 1-foot wide.

B. Contents: Wood chips, bark, straw, or other approved material.

PART 3 EXECUTION

3.01 APPLICATION

A. Erosion control measures are required during all construction and site disturbance activity and shall remain and be maintained until permanent site ground covers are in place.

B. The implementation of the erosion control plan and the construction maintenance, replacement, and upgrading the erosion control devices are the responsibility of the Contractor until all construction is completed. During the construction period, the erosion control devices shall be upgraded for unexpected storm events and to ensure that sediment and sediment-laden water do not leave the Site.

C. Maintain existing buffer zones adjacent to project limits. Keep all construction equipment, debris, and soils out of the natural buffer zone.

3.02 CONSTRUCTION ENTRANCE

A. Provide graveled construction accesses at locations shown on the Drawings.

B. Construction entrance shall comply with CWS Standard Drawing No. 855.

C. Contractor shall maintain construction entrance to ensure proper function.

3.03 SOIL PREPARATION

A. Areas to be seeded shall be graded and prepared for placement of topsoil. Native topsoil shall be salvaged and stockpiled, and shall be placed on areas to be restored. Prior to placement of topsoil all debris and trash shall be removed from areas to be seeded.

3.04 SEEDING

A. Verify that grading and soil preparation has been completely corrected.

B. Apply by hydroseeding method with approved hydraulic seeding equipment on moist soil, but only after free surface water has drained away. Seed shall be distributed uniformly over designated areas. Half of seed shall be sown in one direction, and the remainder with sower moving at right angles to first sowing. Prevent drift and displacement of mixture into other areas. On slopes steeper than 10 percent, hydroseed and mulch shall be applied with a bonding agent (tackifier).

C. Application:

1. Prepare and apply slurry as follows:
   a. Seed Mix: 90 pounds per acre.
   b. Fertilizer: 100 pounds per acre.
   c. Wood Cellulose Fiber Mulch: 2,000 pounds per acre.
   d. Water: As necessary.

D. Satisfactory Seeded Areas: Unless otherwise specified all seeded areas shall at end of maintenance period, exhibit a healthy, uniform, close stand of the specified seed mix, free of weeds and surface irregularities, with coverage of mix in specified proportions.

E. Reestablish seeded areas that do not comply with requirements and continue maintenance until seeded areas are satisfactory.

3.05 MULCHING

A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by Engineer, and on all seeded areas with a slope steeper than 5 percent. Do not apply mulch on seeded areas that will be immediately covered with erosion control matting.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion or underlying soil.

1. Wood Cellulose Fiber Mulch: 2,000 pounds per acre.

3.06 EROSION CONTROL MATTING

A. Place on Seeded Slopes: 4H:1V and steeper; on ground surfaces and stockpiles exposed during wet weather season (October 15 through April 30); and as a temporary measure to provide erosion protection and assist in germination on areas seeded between October 15 through April 30.

B. Apply seed and fertilizer prior to matting.

3.07 SOIL TACKIFIER

A. Apply on areas mulched.

B. Spray on after mulch is in place.

C. The soil tackifier shall be applied at the rate per acre specified by manufacturer for applicable grades.

3.08 REINFORCED PLASTIC COVERING

A. Place on areas where hydroseeding and erosion control matting have not controlled erosion, and over all temporary stockpiles.

B. Install per CWS Standard Drawing No. 810.

3.09 SEDIMENT FENCE

A. Install prior to starting earth disturbing activities.

B. One-piece filter fabric or continuously sewn to make one-piece filter fabric for full height of fence, including portion buried in the toe trench.

C. Remove silt fence after area has been permanently stabilized.

D. Sediment fence shall comply with CWS Standard Drawing No. 875.

3.10 TEMPORARY SOIL STOCKPILES

A. Cover temporary soil stockpile as required to prevent erosion per CWS Standard Drawing No. 810.

3.11 DUST CONTROL

A. Apply appropriate dust control measures on a continuous basis until permanent stabilization measures are in place.

B. Apply on construction routes and other disturbed areas subject to surface dust movement and where offsite damage may occur if dust is not controlled.

C. Avoid creating erosion when using water as a dust controller.

3.12 TEMPORARY CATCH BASIN PROTECTION

A. Install biofilter bags at all catch basins shown on the Drawings.

END OF SECTION

SECTION 02371
GEOTEXTILE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. D737, Standard Test Method for Air Permeability of Textile Fabrics.
   b. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   c. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   d. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   e. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   f. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
   h. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   i. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   j. D4886, Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper or Sliding Block Method).
   k. D5199, Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
   l. D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.

D. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

E. Standard Specifications: When referenced in this section, shall mean Oregon Standard Specifications for Construction, 2021.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer material specifications and product literature.

B. Informational Submittals: Certifications from each geotextile manufacturer that furnished products have specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 02319, Subgrade Preparation, first.

B. Notify Engineer whenever geotextiles are to be placed. Do not place geotextile without Engineer’s approval of underlying materials.

PART 2 PRODUCTS

2.01 SUBGRADE GEOTEXTILE

A. Nonwoven geotextile.

B. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

C. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

D. Unseamed Sheet Width: Minimum 12 feet.

E. Physical Properties: Conform to requirements for nonwoven Subgrade Geotextile (Separation) as specified in Table 2320-4 in Section 02320.20, Geotextile Property Values, of Standard Specifications.

PART 3 EXECUTION

3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

3.03 JOINTS

A. Unseamed Joints:

1. Overlapped.
2. Overlap, unless otherwise shown:
    a. Foundation or Subgrade Stabilization: Minimum 18 inches.
    b. Riprap: Minimum 18 inches.
    c. Drain Trenches: Minimum 18 inches, except overlap shall equal trench width if trench width is less than 18 inches.
    d. Other Applications: Minimum 12 inches.

3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sandbags or other means approved by Engineer.

B. Secure Geotextile with Securing Pins or Staples:

1. Insert securing pins with washers through geotextile.
2. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.
3. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.
4. Where staples are used instead of securing pins, install in accordance with alignment and spacing above. Push in to secure geotextile firmly to subgrade.

3.05 PLACING PRODUCTS OVER GEOTEXTILE

A. Before placing material over geotextile, notify Engineer. Do not cover installed geotextile until after Engineer provides authorization to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain material to be placed in trench and with specified overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to required grade, fold geotextile over top of granular drain material, unless otherwise shown. Maintain overlap until overlying fill or backfill is placed.

3.07 SILT FENCE APPLICATIONS

A. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

3.08 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile.

B. Repair Procedure:

1. Place patch of undamaged geotextile over damaged area and at least 18 inches in all directions beyond damaged area.
2. Remove interfering material as necessary to expose damaged geotextile for repair.
3. Sew patches or secure them with heat fusion tacking or with pins and washers, as specified above in Article Securing Geotextile, or by other means approved by Engineer.

3.09 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Engineer’s opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION

SECTION 02600
MANHOLES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): M198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A536, Standard Specification for Ductile Iron Castings.
   e. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   f. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
   g. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   h. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   i. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   j. C150/C150M, Standard Specification for Portland Cement.
   k. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
   l. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. C443, Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   n. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   o. C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   p. C990, Standard Specification for Joints in Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants.
   q. C1311, Standard Specification for Solvent Release Sealants.

r. C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
s. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-lbf/feet3 (600 kN-m/m3)).
t. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
u. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
v. F594, Standard Specification for Stainless Steel Nuts.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings including details of construction, reinforcing and joints, anchors, lifting, external straps, erection inserts, and other items cast into members.
2. Product Data:
   a. Concrete mix design.
   b. Manhole frame to structure seals.
   c. Manhole frame to structure anchor bolt.
   d. Rubber gaskets and sealants.
   e. External joint wrap.

B. Informational Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification.
2. Calculations: Proposed details and design calculations for stresses in precast concrete members for loading conditions including earth pressures and transportation, handling, and erection. Calculations shall be stamped by engineer registered in the state of Oregon.
3. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
4. Test Reports:
   a. Precast manufacturer’s concrete test cylinders.
   b. Core compression test.
   c. Absorption test.
5. Certified load test data for precast manhole steps.
6. Manufacturer’s recommended installation instructions.
7. Field quality control report.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant: PCI certified plant with current certification.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials of Construction and Service Conditions:

1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
2. Gaskets: Internal and external seals shall be made of materials that have been proven to be resistant to the following exposures and conditions:
   a. Sanitary sewage.
   b. Corrosion or rotting under wet or dry conditions.
   c. Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at installation site.
   d. Biological environment in soils and sanitary sewers.
   e. Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
   f. Temperature ranges, variations, and gradients in construction area.
   g. Variations in moisture conditions and humidity.
   h. Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
   i. Vibrations because of traffic loading.
   j. Fatigue failure because of repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression. Material shall remain flexible allowing repeated movement.
3. Materials shall be compatible with each other and manhole materials.
4. Designed to provide a 20-year service life.

B. Structures shall meet requirements of ASTM C478, this specification and the following:

1. Concrete:
   a. Cement: Meet requirements of ASTM C150/C150M.
   b. Compressive Strength:
      1) Minimum 4,000 pounds per square inch.
      2) Minimum strength shall be confirmed at 7 days by making two standard cylinders per manhole for testing.
2. Reinforcement: Grade 60, unless otherwise specified.
3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
4. Floor: Minimum 12 inches below pipe to provide clearance for grouting channels.
5. Joint:
   a. Form joint contact services with machined castings.
   b. Surfaces shall be parallel with nominal 1/16-inch clearing and tongue equipped with recess for installation of O-ring rubber gasket.
6. Gasket: Meet requirements of ASTM C443.

2.02 PRECAST MANHOLES

A. Riser Sections:

1. Fabricate in accordance with ASTM C478.
2. Diameter: As shown on the Drawings.
3. Wall Thickness: Minimum 4 inches or 1/12 times inside diameter, whichever is greater.
4. Top and bottom surfaces shall be parallel.
5. Joints: Tongue-and-groove and confined O-ring with rubber gaskets meeting ASTM C443.

B. Cone Sections:

1. Same wall thickness and reinforcement as riser section.
2. Top and bottom surfaces shall be parallel.

C. Base Sections and Base Slab:

1. Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.

D. Manhole Extensions:

1. Concrete grade rings; maximum 6 inches high.
2. Fabricate in accordance with ASTM C478.

E. Joint Seal, and Manufacturers and Products:

1. A gasket or O-Ring, and external wrap will be required for joint seal.
2. Butyl Gaskets:
   a. Hamilton Kent, Sparks, NV; Kent-Seal No. 2.
   b. Henry Company, Houston, TX; Ram-Nek.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC Bidco C-56.
3. Confined Plastic or Rubber O-Ring:
   a. As recommended by precasting manufacturer.
   b. Meet requirements of ASTM C443.
4. External Wrap:
   a. Sealing Systems, Inc., Loretto, MN; Gator Wrap.
   b. Henry Company, Houston, TX; RU116 Rubr-Nek External Joint Wrap.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC External Joint Wrap.
   d. Cretex Specialty Products, Waukesha, WI; Cretex Wrap.

2.03 CAST-IN-PLACE MANHOLES

A. Concrete: As specified in Section 03300, Cast-in-Place Concrete.

B. Reinforcing Steel: As specified in Section 03210, Steel Reinforcement.

2.04 MANHOLE FRAMES AND COVER

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48/A48M Class 30B.
3. Ductile Iron: ASTM A536, Grade 60-40-12.
4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Cover: Owner’s Standard. See Clean Water Services Standard Drawing 110. True and seat within ring at all points. With the word DRAIN in 2-inch raised letters.

2.05 MORTAR

A. Standard premixed in accordance with ASTM C387/C387M, or proportion one part portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.

B. Admixtures:

1. May be included; do not exceed the following percentages of weight of cement:
   a. Hydrated Lime: 10 percent.
   b. Diatomaceous Earth or Other Inert Material: 5 percent.

C. Mix Consistency:

1. Tongue-and-Groove Type Joint: Such that mortar will readily adhere to pipe.
2. Confined Groove (Keylock) Joint: Such that excess mortar will be forced out of groove and support is not provided for section being placed.

2.06 BACKFILL AROUND AND UNDER MANHOLE

A. Structural fill as specified in Section 02316, Fill and Backfill.

2.07 FLEXIBLE JOINTS FOR SEALING PIPES IN MANHOLE

A. Manufacturers and Products:

1. NPC, Inc., Milford, New Hampshire; Kor-N-Seal flexible rubber boot with stainless steel accessories.
2. A-LOK Products, Inc., Tullytown, PA; Z-LOK XP or A-LOK flexible connectors.

2.08 SOURCE QUALITY CONTROL

A. Prior to delivery of precast manhole sections to Site, yard permeability tests may be required at point of manufacture. Test specimens shall be mat tested and meet permeability test requirements of ASTM C14.

B. Concrete Testing: Test two concrete test cylinders for each manhole. Compressive strength shall be tested in accordance with ASTM C31/C31M, ASTM C39/C39M, and ASTM C192/C192M.

C. Inspection:

1. Material Quality:
   a. Manufacturing process and finished sections shall be subject to inspection and approval by Owner and Engineer.
      1) Inspections may take place at manufacturer's plant, at Site after delivery, or at both.
      2) Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
      3) Sections rejected after delivery shall be removed and replaced.
      4) Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
      5) If structure cannot be repaired it shall be removed and replaced entirely at Contractor's expense.
2. At the time of inspection the sections will be carefully examined for compliance with ASTM C478 and with manufacturer's drawings. Sections will be inspected for general appearance, dimensions, scratch strength, blisters, cracks, roughness, and soundness. Surface shall be dense and close textured.
3. Imperfections may be repaired, subject to approval of Engineer, after demonstration by manufacturer that strong and permanent repairs result.

PART 3 EXECUTION

3.01 GENERAL

A. Prior to installation inspect materials:

1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
3. Remove and replace structure that cannot be repaired.

B. If needed, dewater excavation during construction and testing operations.

3.02 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 02315, Excavation.

B. Backfill:

1. As specified in Section 02316, Fill and Backfill.
2. Place structural fill under manhole in 6-inch maximum lifts; minimum of 12 inches unless otherwise specified on the Drawings. Compact each lift to 98 percent relative compaction as determined in accordance with ASTM D698.

3.03 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:

1. Precast:
   a. Place on compacted structural fill.
   b. Properly locate, ensure firm bearing throughout, and plumb first section.
2. Cast-in-Place:
   a. Invert: Minimum 8 inches below lowest connecting pipe.
   b. First section of manhole shall be cast in concrete base.

B. Sections:

1. Inspect precast manhole sections to be joined.
2. Clean ends of sections to be joined.
3. Do not use sections with chips or cracks in tongue.
4. Locate precast steps in line with each other to provide continuous vertical ladder.

C. Preformed Plastic Gaskets or Rubber O-Ring:

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer’s instructions.
3. Completed Manhole: Rigid and watertight.

D. Mortar Joints for Grade Rings:

1. Thoroughly wet joint with water prior to placing mortar.
2. Place mortar on groove of lower section prior to section installation.
3. Fill joint completely with mortar of proper consistency.
4. Trowel interior and exterior surfaces smooth on standard tongue-and-groove joint.

5. Prevent mortar from drying out and cure by applying approved curing compound or comparable approved method.
6. Do not use mortar mixed for longer than 30 minutes.
7. Chip out and replace cracked or defective mortar.
8. Completed Manhole: Rigid and watertight.

E. External Joint Wraps: Install in accordance with manufacturer's instructions.

F. Extensions:

1. Provide on manholes in streets or other locations where change in existing grade may be likely.
2. Install to height not exceeding 12 inches.
3. Lay grade rings in mortar with sides plumb and tops level.
4. Seal joints with mortar as specified for sections and make watertight.

3.04 MANHOLE FRAMES AND COVERS

A. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

B. Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.

C. Anchor frame to manhole with specified bolts.

D. Install manhole frame to structure seals in accordance with manufacturer's instructions. Seal shall cover grade rings.

3.05 MANHOLE PIPING

A. Drop Assembly: See the Drawings for detail of installation requirements.

B. Flexible Joints:

1. Provide in pipe not more than 1-1/2 feet from manhole walls.
2. Where last joint of pipe is between 1-1/2 feet and 6 feet from manhole wall, provide flexible joint in manhole wall.

3.06 CONNECTIONS TO EXISTING MANHOLES

A. Core manhole bases and grouting as necessary.

B. Seal pipe in manhole using flexible connector.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.07 FIELD QUALITY CONTROL

A. Conduct negative air pressure (vacuum) test on all manholes in accordance with ASTM C1244.

B. Hydrostatic Testing:

1. Hydrostatically Test: All manholes.
2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Engineer.
3. Manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into pipe walls to take place.
4. Leakage in each manhole shall not exceed 0.1-gallon per hour per foot of head above invert.
5. Repair manholes that do not meet leakage test, or do not meet specified requirements from visual inspection.
6. If more than 25 percent of manholes tested fail the hydrostatic test, test all or as many manholes as Engineer deems necessary.

END OF SECTION

SECTION 02631
CATCH BASINS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Welding Society (AWS): Code for Welding in Building Construction.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   f. C478, Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed drawings showing complete information for fabrication including, but not limited to:
      1) Member dimensions and cross-sections; location, size, and type of reinforcement, including additional reinforcement.
      2) Layout dimensions and identification of each precast unit.
      3) Details of connections, joints, accessories, and openings or inserts.
      4) Watertight joint details.
   b. Product Data:
      1) Precast concrete items; show materials of construction by ASTM reference and grade.
      2) HS-20 traffic rated.
      3) Joint sealants.

B. Informational Submittals:

1. Manufacturer's data for lifting devices for handling and erection.
2. Manufacturer's certification that catch basin design and manufacture comply with referenced ASTMs (for example, ASTM C857 and ASTM C858).
3. Calculations of the concrete structure catch basin signed by a civil or structural engineer registered in the State of Oregon meeting structural design criteria as stated in Contract Documents.

PART 2 PRODUCTS

2.01 CONCRETE

A. Type: Ready-mixed, conforming to ASTM C94/C94M, Alternate 2.

B. Compressive Field Strength: Not less than 3,000 pounds per square inch at 28 days.

C. Maximum Size of Aggregate: 1-1/2 inches.

D. Slump: Between 2 inches and 4 inches.

E. Assumed Field Strength: 85 percent of strength of laboratory-cured cylinders.

2.02 FORMS

A. Exposed Surfaces: Plywood.

B. Other Surfaces: Steel, matched boards, plywood, or other acceptable material.

1. Trench walls, large rock, and earth are not acceptable form material.

C. Form vertical surfaces.

D. Provide fillets on re-entrant angles.

2.03 REINFORCING STEEL

A. Conform to ASTM A615/A615M, Grade 60, deformed bars.

2.04 PRECAST UNITS

A. At the option of Contractor, approved precast units may be substituted for cast-in-place units.

B. Conform to ASTM C478: Submit details of proposed units to Engineer for review.

C. Concrete Risers for Extensions: 6 inches high maximum and of same quality as sections.

1. Confirm acceptability of risers with Engineer before installation.

2.05 MORTAR

A. Standard premixed mortar conforming to ASTM C387/C387M, Type S, or proportion one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.

B. Admixtures may be used if not exceeding the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. Diatomaceous Earth or Other Inert Materials: 5 percent.

C. Consistency of Mortar: As required to readily adhere to concrete.

2.06 FRAMES AND GRATES

A. Frames and Grates for Catch Basins and Storm Drain Inlets: Steel conforming to ASTM A36/A36M.

B. Connections: Welded in accordance with requirements of current Code For Welding in Building Construction of the American Welding Society.

C. Clean and hot-dip galvanized after fabrication.

PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavate as required to accomplish construction. Backfill as specified for adjoining pipe trench.

3.02 CONSTRUCTION OF CATCH BASINS AND INLETS

A. Construct inlets and catch basins at locations shown and in accordance with the Drawings. Construct tight and well-braced forms to dimensions and elevations required. Chamfer form corners.

B. Prior to placing concrete, remove water and debris from forms. Moisten forms just prior to placing concrete. Handle concrete from transporting vehicle to forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with mechanical vibrator. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

C. Screed top surface of exposed slabs and walls. When initial water has been absorbed, float surfaces with wood float and lightly trowel with steel trowel to smooth finish free from marks or irregularities. Finish exposed edges with steel edging tool. Remove forms and patch defects in concrete with mortar mixed in same proportions as original concrete mix.

D. Use a membrane-forming curing compound to prevent loss of moisture for 7 days. Apply curing compound immediately after removal of forms or finishing of slabs. Protect concrete from damage during curing period.

3.03 PLACING PRECAST UNITS

A. If material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean, pit-run material. Set units to grade at locations shown.

3.04 INSTALLATION OF FRAMES AND GRATES

A. Set frames and grates at elevations indicated or as determined in field and in conformance with the Drawings.

B. Frames may be cast in or set in mortar.

3.05 CLEANING

A. Upon completion, clean structure of silt, debris, and foreign matter.

END OF SECTION

SECTION 02705
STORM DRAIN AND SANITARY SEWER PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and supplemental Data Sheets:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M36, Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
   b. M190, Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe-Arches.
   c. M196, Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
   d. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
   e. M294, Standard Specification for Corrugated Polyethylene Pipe, 300 – 1500 mm (12-inch to 60-inch). Diameter.
2. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C116/A21.16, Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
   f. C150/A21.50, Thickness Design of Ductile Iron Pipe.
   g. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
   h. C153/A21.53, Ductile-Iron Compact Fittings.
3. ASTM International (ASTM):
   a. A746, Standard Specification for Ductile Iron Gravity Sewer Pipe.
   b. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   c. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   d. C150/150M, Standard Specification for Portland Cement.

e. C311/311M, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete.
f. C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
g. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
h. C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
i. C497, Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile.
j. C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
k. C595/595M, Standard Specification for Blended Hydraulic Cements.
l. C618, Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
m. C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.
n. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
o. C1012/1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
p. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
q. D1784, Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
r. D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
s. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
t. D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
u. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
v. F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
w. F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
x. F894, Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

1.02 SUBMITTALS

A. Informational Submittals: Manufacturer's Certification of Compliance.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. As specified in the Data Sheets following "End of Section."

PART 3 EXECUTION

3.01 INSTALLATION OF PIPE, FITTINGS, AND APPURTENANCES

A. General:

1. Lay pipe up-grade with spigot ends pointing in direction of flow.
2. Excavate bell holes at each joint to permit correct assembly and inspection of entire joint.
3. Pipe invert may deviate from line or grade up to 1/2-inch for line and 1/4-inch for grade, provided that finished pipe line will present a uniform bore, and such variation does not result in a level or reverse sloping invert, or less than minimum slope shown.
4. Bed pipe to form continuous and uniform bearing and support for pipe barrel between joints. Do not rest pipe directly on bell or pipe joint.
5. Prevent entry of foreign material into gasketed joints.
6. Plug or close off pipes that are stubbed off for manhole, concrete structure, or for connection by others, with temporary watertight plugs, unless indicated otherwise.

3.02 SEWER CLEANING

A. Prior to final acceptance and final manhole-to-manhole inspection of the sewer system by Engineer, flush and clean the system. Remove accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the sewer system at or near the closest downstream manhole. Use mechanical rodding or bucketing equipment where flushing does not remove debris.

B. Upon Engineer's final manhole-to-manhole inspection of the sewer system, if foreign matter is still present in the system, reflush and clean the sections and portions of the lines.

3.03 SUPPLEMENTS

A. Data Sheets:

Number	Title
-.03	Polyvinyl Chloride (PVC)

END OF SECTION

SECTION 02705.03 POLYVINYL CHLORIDE (PVC)	
Item	**Description**
Pipe: 15-inch diameter and under	ASTM D3034: Standard dimension ratio less than 35, except that the cell classification shall be 12454-B or 12454-C as defined in ASTM D1784.
Pipe: 18-inch through 24-inch diameter	ASTM F679: Minimum wall thickness per Table 1 of ASTM F679, except that the cell classification shall be 12454-C as defined in ASTM D1784.
Ribbed Profile Pipe: 18-inch through 48-inch diameter	ASTM F794: Minimum stiffness of 46 pounds per square inch when tested in accordance with ASTM D2412, except that the cell classification shall be 12454-C as defined in ASTM D1784.
Joints	ASTM D3212 rubber gasketed.
Gaskets	ASTM F477. Lubricants: As approved by manufacturer.
Fittings	PVC, gasketed. Provide plug when service piping is not required.
Plugs	Removable. Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.
Source Quality Control Testing	In accordance with specified ASTM.

END OF SECTION

SECTION 02710
AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.
   b. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   c. C117, Standard Method of Test for Materials Finer Than 75μm (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C131, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   e. C183, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   f. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-pounds/feet^3 (600 kN-m/m^3)).
   g. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-pounds/feet^3 (2700 kN-m/m^3)).
   h. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
   i. D2216, Standard Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
   j. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   k. D2844, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
   l. D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
   m. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   n. D5195, Standard Test Methods for Density of Soil and Rock In-Place Below Surface by Nuclear Methods.
   o. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Base Course: Crushed aggregate or similar as specified placed and compacted on prepared subgrade or subbase course.

B. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

C. Completed Lift: Compacted with uniform cross-section thickness.

D. Gravel Surfacing: Aggregate used for construction of low-volume access and staging area that can be easily graded and compacted.

E. Leveling Course: Crushed aggregate placed and compacted on base course to be used for finish grading.

F. Standard Specifications: When referenced in this section, shall mean the Oregon Standard Specifications for Construction, 2021.

G. Subbase Course: Sandy, gravelly material placed and compacted on prepared subgrade.

1.03 SUBMITTALS

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.
2. Certified results of in-place density tests from independent testing agency.

PART 2 PRODUCTS

2.01 AGGREGATE BASE COURSE

A. As specified for 3/4-inch maximum base aggregate in Section 02630, of the ODOT Standard Specifications.

2.02 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPA RATION

A. As specified in Section 02319, Subgrade Preparation.

B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. In accordance with Section 00641, of the ODOT Standard Specifications.

B. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

C. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Aggregate Base Course:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.
5. Add keystone to achieve compaction and as required when aggregate does not compact readily because of lack of fines or natural cementing properties, as follows:
   a. Use surfacing material as keystone.
   b. Spread evenly on top of base course, using spreader boxes or chip spreaders.
   c. Roll surface until keystone is worked into interstices of base course without excessive displacement.
   d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

B. Gravel Surfacing:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on preceding course in accordance with cross-section shown.
4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

A. In accordance with Section 00641, of the ODOT Standard Specifications, except as modified hereinafter.

B. Commence compaction of each layer of base and gravel surfacing after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by ASTM D1557.

C. Roll each layer of material until material does not creep under roller before succeeding layer is applied.

D. Commence rolling at outer edges and continue toward center; do not roll center of road first.

E. Apply water as needed to obtain specified densities.

F. Place and compact each lift to the required density before succeeding lift is placed.

G. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

H. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.06 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base Course: Within plus or minus 0.04-foot of grade shown at any individual point.

C. Gravel Surfacing: Within 0.04-foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

D. Overall Average: Within plus or minus 0.01-foot from crown and grade specified.

3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Provide testing laboratory at least 24 hours' advance notification prior to testing.
2. Show proof that areas meet specified requirements before identifying density test locations.

3.08 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

SECTION 02771
CURBS, GUTTERS, AND SIDEWALKS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T 99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5-pound) Rammer and a 305 mm (12 inches) Drop.
2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ASTM International (ASTM):
   a. C94, Standard Specification for Ready-Mixed Concrete.
   b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

1.02 DEFINITIONS

A. Standard Specification: When referenced in this section, shall mean the Oregon Standard Specifications for Construction, 2021.

1.03 SUBMITTALS

A. Action Submittals:

1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

B. Informational Submittals:

1. Curing Compound: Manufacturer’s Certificate of Compliance, in accordance with Section 01600, Product Requirements, and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to Standard Specification Section 00759.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conform to the requirements of the referenced Standard Specification.

2.02 EXPANSION JOINT FILLER

A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.03 CONCRETE

A. Ready-mixed meeting ASTM C94, Option A, with compressive strength of 3,300 pounds per square inch at 28 days.

B. Maximum Aggregate Size: 1-1/2 inches.

C. Slump: 2 inches to 4 inches.

D. Concrete for curbs shall be fiber reinforced.

2.04 CURING COMPOUND

A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Perform Work in accordance with the referenced Standard Specification.

3.02 FORMWORK

A. Lumber Materials:

1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed curb and sidewalk.
2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.

B. Metals: Steel in new undamaged condition.

C. Setting Forms:

1. Construct forms to shape, lines, grades, and dimensions.
2. Stake securely in place.

D. Bracing:

1. Brace forms to prevent change of shape or movement resulting from placement.
2. Construct short-radius curved forms to exact radius.

E. Tolerances:

1. Do not vary tops of forms from gradeline more than 1/8-inch when checked with 10-foot straightedge.
2. Do not vary alignment of straight sections more than 1/8-inch in 10 feet.

3.03 PLACING CONCRETE

A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.

B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.

C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.

D. To compact, vibrate until concrete becomes uniformly plastic.

3.04 CURB CONSTRUCTION

A. Construct ramps at pedestrian crossings.

B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of curb, and at connections to existing curbs. Install expansion joint filler at each joint.

C. Curb Facing: Do not allow horizontal joints within 7 inches from top of curb.

D. Contraction Joints:

1. Maximum 15-foot intervals in curb.
2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
3. Insert steel sheet to full depth of curb.
4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
5. Finish top of curb with steel trowel and finish edges with steel edging tool.

E. Front Face:

1. Remove front form and finish exposed surfaces when concrete has set sufficiently to support its own weight.
2. Finish formed face by rubbing with burlap sack or similar device to produce uniformly textured surface, free of form marks, honeycomb, and other defects.
3. Remove and replace defective concrete.
4. Apply curing compound to exposed surfaces of curb upon completion of finishing.
5. Continue curing for minimum of 5 days.

F. Backfill curb with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.

1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
2. Compact backfill firmly.

3.05 SIDEWALK CONSTRUCTION

A. Thickness:

1. 4 inches in walk areas.
2. 6 inches in driveway areas.

B. Connection to Existing Sidewalk:

1. Remove old concrete back to an existing contraction joint.
2. Clean the surface.
3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place in adjacent curb, where sidewalk ends at curb, and around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:

1. Provide transversely to walks at locations opposite contraction joints in curb.
2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
3. Construct straight and at right angles to surface of walk.

E. Finish:

1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
2. Mark walks transversely at 5-foot intervals with jointing tool; finish edges with rounded steel edging tool.
3. Apply curing compound to exposed surfaces upon completion of finishing.
4. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

SECTION 02772
ASPHALT PAVING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
   b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
   c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
   d. M140, Standard Specification for Emulsified Asphalt.
   e. M156, Standard Specification for Requirements for Mixing Plants for Hot-mixed, Hot-laid Bituminous Paving Mixes.
   f. M208, Standard Specification for Cationic Emulsified Asphalt.
   g. R35, Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt.
   h. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   i. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   j. T209, Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA).
   k. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
   l. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus.
   m. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
   n. T283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage.
   o. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.

p. T312, Standard Method of Test for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyratory Compactor.

2. Asphalt Institute (AI):
   a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
   b. Superpave Series No. 2 (SP-2), Superpave Mix Design.
3. ASTM International (ASTM):
   a. D75, Standard Method of Test for Sampling of Aggregates.
   b. D140, Standard Method of Test for Sampling Bituminous Materials.
   c. D979, Standard Method of Test for Sampling Bituminous Paving Mixtures.
   d. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
   e. D2489, Standard Method of Test for Determining Degree of Particle Coating of Asphalt Mixtures.
   f. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   g. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   h. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
   i. E329 REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.

1.02 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

B. Maximum Aggregate Size: One sieve size larger than the nominal aggregate size.

C. Nominal Aggregate Size: One sieve size larger than the first sieve that retains more than 10 percent aggregate.

D. Reclaimed Asphalt Pavement (RAP): Removed and/or processed pavement materials containing binder and aggregate.

E. Seal Coat: Term used for various applications of emulsified asphalt, with or without sand or aggregate, to protect the asphalt surface from aging due to wear, degradation from the sun, wind, and water. Also used to improve skid resistance and aesthetics. The term seal coat can be used to define fog seal, slurry seal, chip seal or sand seal, depending on application.

F. Standard Specifications: Oregon Standard Specifications for Construction, 2021.

G. Tack Coat: Thin layer of emulsified asphalt applied to hard surfaces, including new pavement lifts, to promote adhesion and bonding.

1.03 DESIGN REQUIREMENTS

A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements of this specification.

1.04 SUBMITTALS

A. Informational Submittals:

1. Asphalt Concrete Mix Formula:
   a. Submit minimum of 15 days prior to start of production.
   b. Submittal to include the following information:
      1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate as specified within Section 00744.12 of the Standard Specifications.
      2) Bulk specific gravity for each aggregate constituent.
      3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
      4) Job mix formula properties demonstrating conformance with the mix requirements specified in Section 00744.13 of the Standard Specifications.
      5) Properties as stated in Section 00744 of the Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
      6) Percent of asphalt lost due to absorption by aggregate.
      7) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
      8) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
      9) Optimum mixing temperature.
      10) Optimum compaction temperature.
      11) Temperature-viscosity curve of asphalt cement to be used.
      12) Brand name of any additive to be used and percentage added to mixture.

2. Test Report for Asphalt Cement:
   a. Submit minimum 10 days prior to start of production.
   b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer's installation instructions for pavement fabric.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements, for the following materials:
   a. Aggregate: Gradation, source test results as defined in Section 00744.12 of the Standard Specifications.
   b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
   c. Prime Coat: Type and grade of asphalt.
   d. Tack Coat: Type and grade of asphalt.
   e. Additives.
   f. Mix: Conforms to job-mix formula.
   g. Pavement fabric.
5. Statement of qualification for independent testing laboratory.
6. Test Results:
   a. Mix design.
   b. Asphalt concrete core.
   c. Gradation and asphalt content of uncompacted mix.
   d. Field density.
   e. Quality control.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329 REV A.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.
3. Ensure that a trained Manufacturer's Technical Representative is present during every phase of installation, unless applied by a factory trained licensed installer, as indicated by written approval from the material supplier. The Manufacturer's Technical Representative will provide training and technical assistance on surface preparation, equipment, method of application and finish.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 50 degrees F (10 degrees C) or air temperature is lower than 40 degrees F (4 degrees C). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tack Coat:

1. Emulsified Asphalt for Tack Coat or Seal Coat: Conform to Section 00730 of the Standard Specifications.

2.02 ASPHALT CONCRETE MIX

A. General:

1. Mix formula shall not be modified except with written approval of Engineer.
2. Source Changes:
   a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
   b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Engineer to confirm that properties are in compliance with design criteria.
   c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Asphalt Concrete: Level 3, 1/2-inch Dense Graded Asphalt Concrete Pavement (ACP) as specified in Section 00744 of the Standard Specifications.

C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

D. Aggregate:

1. General: As specified in Section 00744.10 of the Standard Specifications.

E. Mineral Filler: In accordance with AASHTO M17.

F. Asphalt Cement: Paving Grade 70-22.

2.03 PAVEMENT FABRIC

A. Meeting the requirements of AASHTO M288, Paving Fabrics Type II. Provide a stable fiber, needle-punched, nonwoven material consisting of at least 85 percent by weight polyolefins, polyesters or polyamides. The paving fabric shall be resistant to chemical attack, rot and mildew and have no tears or defects that will adversely alter its physical properties. The fabric shall be specifically designed for pavement applications and be heat-set on one side to reduce tack coat bleed-through and to minimize fabric pick-up by construction equipment during installation. Identify each geotextile paving fabric roll according to ASTM D4873.

B. Identify each paving fabric roll according to ASTM D4873.

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control:

1. In accordance with Section 01500, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

3.02 LINE AND GRADE

A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.

3.03 APPLICATION EQUIPMENT

A. In accordance with Section 00745.20, Section 00745.21, Section 00745.22, Section 00745.23, and Section 00745.24 of the Standard Specifications.

3.04 PREPARATION

A. Prepare subgrade as specified in Section 02319, Subgrade Preparation.

B. Existing Roadway:

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 2 inches (50 millimeters).
3. Paint edges of meet line with tack coat prior to placing new pavement.

C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

3.05 PAVEMENT APPLICATION

A. General: Place asphalt concrete mixture on approved, prepared base in conformance with this section.

B. Tack Coat:

1. Prepare material, as specified in Section 00730 of the Standard Specifications, prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
3. Do not apply more tack coat than necessary for the day’s paving operation.
4. Touch up missed or lightly coated surfaces and remove excess material.
5. Application Rate:
   a. 0.05-gallon per square yard to 0.15-gallon per square yard (0.25-liter per square meter to 0.70-liter per square meter) of asphalt (residual if diluted emulsified asphalt).
   b. Apply at rate, within range specified, sufficient to assure good bonding, but not so heavy that surplus asphalt flushes into asphalt concrete being placed.

C. Pavement Mix:

1. Prior to Paving:
   a. Sweep primed surface free of dirt, dust, or other foreign matter.
   b. Patch holes in primed surface with asphalt concrete pavement mix.
   c. Blot excess prime material with sand.

2. Place asphalt concrete pavement mix as shown.
3. Compacted Lift Thickness:
    a. Minimum: Twice maximum aggregate size, but in no case less than 1-inch (25 millimeters).
    b. Maximum: 2 inches (50 millimeters).
4. Total Compacted Thickness: As shown.
5. Sequence placement so that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
    a. Offset edge of each layer a minimum of 6 inches (150 millimeters) so joints are not directly over those in underlying layer.
    b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
    c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 6 inches (150 millimeters) on each side of joint with cutback or emulsified asphalt. Cover immediately with sand.

D. Compaction:

1. Roll until roller marks are eliminated and density of 92 percent of measured maximum density determined in accordance with ASTM D2041is obtained.
2. Joint Compaction:
    a. Place top or wearing layer as continuously as possible.
    b. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.
    c. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
    d. Cut away waste material and lay new mix against fresh cut.

E. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Surface or Wearing Layer Smoothness:
   a. Uniform texture, smooth, and uniform to crown and grade.
   b. Maximum Deviation: 1/8-inch (3 millimeters) from lower edge of a 12-foot (3.6-meter) straightedge, measured continuously parallel and at right angle to centerline.
   c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
3. Transverse Slope Maximum Deviation: 1/4-inch (6 millimeters) in 12 feet (3.6 meters) from rate of slope shown.
4. Finished Grade:
   a. Perform field differential level survey on maximum 50-foot (15-meter) grid and along grade breaks.
   b. Maximum Deviation: 0.02-foot (6 millimeters) from grade shown.

3.06 PAVEMENT FABRIC

A. Shipping and Storage: Keep paving fabric dry and wrapped so it is protected from outdoor weather elements during shipping and storage. Store geotextile paving fabric elevated off the ground and covered to protect it from damage, ultraviolet light, precipitation, chemicals, and sparks. The paving fabric shall be labeled according to ASTM D4873, “Standard Guide for Identification, Storage, and handling of Geosynthetic Rolls and Samples.”

B. Weather Limitations: Do not place asphalt material and paving fabric when weather conditions are not suitable for installation according to the fabric manufacturers recommendations.

C. Surface Preparation: Dry and clean pavement surface of dirt and oil. Seal cracks and allow crack-filling material to cure before placement of the geotextile paving fabric. Repair potholes and other pavement distresses as needed.

D. Geotextile Paving Fabric Placement: Place the paving fabric onto the asphalt material using mechanical or manual laydown equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. Place geotextile paving fabric before the asphalt cement cools and loses its tackiness. Do not install geotextile paving fabric in areas where the overlaid asphalt tapers to a minimum compacted thickness of less than 1.5 inches. Slice and lay flat wrinkles severe enough to cause folds. Brooming and/or rubber-tire rolling will be required to maximize geotextile paving fabric contact with the pavement surface. Turning of the paver and other vehicles must be done gradually and kept to a minimum to avoid movement and damage to geotextile paving fabric. Avoid abrupt starts and stops to avoid damage to paving fabric. Remove damaged geotextile fabric and replace with same type of geotextile fabric.

E. At joints, overlap fabric rolls by a 1-inch minimum. End joints and joints from repair of wrinkles must be made to overlap or “shingle” in the direction that the pavement overlay will be placed. Overlaps of adjacent rolls may vary due to variations between the width of the roadway and paving fabric.

F. Asphalt Application over Pavement Fabric: Apply asphalt material using a calibrated distributor truck spray bar. Hand spraying, squeegee and brush application may only be used in locations where the distributor truck cannot reach. Make every effort to keep hand application to a minimum. Apply asphalt material uniformly to the prepared, clean, dry pavement surface. The application rate must saturate the geotextile paving fabric to ensure bonding of the geotextile fabric to the existing pavement surface. Apply asphalt material at a rate of 0.22-gallon to 0.28-gallon per square yard as required to completely cover the roadway and as approved by the Manufacturer’s Technical Representative. Maintain the temperature of the asphalt material to allow a uniform spray pattern. For performance grade asphalt binders, the minimum temperature will be 290 degrees F. Asphalt material temperature must not exceed 350 degrees F to avoid damage to the geotextile paving fabric. The target width of the asphalt material application will be equal to the paving fabric width plus 6 inches. Asphalt material application must be wide enough to cover the entire width of geotextile fabric overlaps. Apply asphalt material only as far in advance of geotextile paving fabric installation as is appropriate to ensure a tacky surface at the time of geotextile paving fabric placement. Do not allow traffic on the tack coat. Clean excess tack coat from the pavement.

3.07 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
   a. Asphalt Content, Aggregate Gradation: Once per every 500 tons (400 mg) of mix or once every 4 hours, whichever is greater.
   b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 1,000 tons (900 mg) or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons (450 mg) of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 03100
CONCRETE FORMING AND ACCESSORIES

PART 1 GENERAL

1.01 DEFINITIONS

A. Architectural Concrete: See definition in Section 03300, Cast-in-Place Concrete.

B. Defective Areas: See definition in Section 03300, Cast-in-Place Concrete.

C. Exposed Concrete: See definition in Section 03300, Cast-in-Place Concrete.

1.02 DESIGN REQUIREMENTS

A. Design formwork in accordance with ACI 301 and ACI 318 to provide concrete finishes specified in Section 03300, Cast-in-Place Concrete.

B. Unless otherwise specified, limit deflection of facing materials for concrete surfaces to comply with ACI 301. Limit deflection of facing materials to comply with tolerance limits established by Contract Documents and with tolerances required by equipment manufacturers. Coordinate tolerance requirements with equipment manufacturers.

C. Coordinate requirements between embedded concrete liner manufacturer and form liner manufacturer.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Formwork drawings signed and sealed by a licensed professional engineer in the state of the Project.
2. Product Data:
    a. Form release agent.
    b. Form ties.
    c. Products to be used for sealing tie holes.

B. Informational Submittals: Statement of qualifications for formwork designer.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Formwork Designer: Formwork, falsework, and shoring design shall be designed by an engineer licensed in the state of Project.

PART 2 PRODUCTS

2.01 FORM MATERIALS

A. Wall Forms and Underside of Slabs and Beams:

1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
2. Where steel forms are used, treat steel surfaces to prevent rusting using products approved for use on steel forms.
3. Circular Structure:
   a. Wall forms shall conform to circular shape of structure.
   b. Straight panels may be substituted for circular forms provided panels do not exceed 2 feet in horizontal width and angular deflection is no greater than 3-1/2 degrees per joint.

B. Column Forms:

1. Rectangular Columns: As specified for walls.
2. Circular Columns: Fabricated steel or fiber-reinforced plastic with bolted sections or spirally wound laminated fiber form. Internally treat with release agent for full height of column.

C. Sandblasted Surface Forms: Medium-density overlay plywood for flat concrete surfaces to be sandblasted.

D. Painted Surface Forms: High-density overlay plywood for flat concrete surfaces to be painted.

E. All Other Forms: Materials as specified for wall forms.

F. Leave in Place Forms: Leave in place forms are not permitted.

2.02 ACCESSORIES

A. Form Release Agent:

1. Material:
   a. Shall not bond with, stain, or adversely affect concrete surfaces.
   b. Shall not impair subsequent treatments of concrete surfaces when applied to forms.
   c. Ready-to-use water based material formulated to reduce or eliminate surface imperfections.
   d. Contain no mineral oil or organic solvents.
2. Manufacturers and Products: Not for surfaces exposed to potable water.
   a. BASF, Shakopee, MN; MBT MasterFinish RL 211.
   b. Cresset Chemical Company; Crete-Lease 20-VOC-Xtra.

B. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Snap-Ties:

1. Material: Stainless steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.
4. Flat bar ties for panel forms; furnish plastic or rubber inserts with minimum 1-1/2-inch depth and sufficient dimensions to permit patching of tie hole.

D. Form Snap-Ties with Water Stop:

1. For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
   a. Integral steel water stop 0.103-inch thick and 0.625-inch diameter tightly and continuously welded to tie.
   b. Neoprene water stop 3/16-inch thick and 15/16-inch diameter whose center hole is one-half diameter of tie, or molded plastic water stop of comparable size.
   c. Orient water stop perpendicular to tie and symmetrical about center of tie.
   d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

E. Through-Bolts: Through-Bolts are not permitted.

F. She-Bolts: She-bolts are not permitted.

PART 3 EXECUTION

3.01 FORM SURFACE PREPARATION

A. Prior to coating surface, thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants.

B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by manufacturer.

C. Steel Forms: Apply form release agent as soon as they are cleaned to prevent discoloration of concrete from rust.

3.02 ERECTION

A. General: In accordance with ACI 301, unless otherwise specified.

B. Beveled Edges (Chamfer):

1. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
2. Where beveled edges on existing adjacent structures are other than 3/4-inch, obtain Engineer’s approval of size prior to placement of beveled edge.

C. Wall Forms:

1. Do not reuse forms with damaged surfaces.
2. Locate form ties and joints in uninterrupted uniform pattern.
3. Inspect form surfaces prior to installation to ensure conformance with specified tolerances.

D. Form Tolerances:

1. Provide forms in accordance with ACI 117 and ACI 318, and the following tolerances for finishes specified:
   a. See the Schedule of Concrete Finishes in Section 03300, Cast-in-Place Concrete, for beam, column, and wall types related to required form tolerances.

b. Wall Tolerances:
   1) Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
   2) Wall Type W-A:
      a) Plumb within 1/4-inch in 10 feet or within 1-inch from top to bottom for walls over 40 feet high.
      b) Depressions in Wall Surface: Maximum 5/16-inch when 10-foot straightedge is placed on high points in all directions.
   3) Wall Type W-B:
      a) Plumb within 1/8-inch in 10 feet or within 1/2-inch from top to bottom for walls over 40 feet high.
      b) Depressions in Wall Surface: Maximum 1/8-inch when 10-foot straightedge is placed on high points in all directions.
   4) Thickness: Maximum 1/4-inch minus or 1/2-inch plus from dimension shown.
   5) Form Offset: Between adjacent pieces of formwork, facing material shall not exceed 1/4-inch.

c. Beams and Columns Tolerances:
   1) Exposed Straight Horizontal and Vertical Surfaces: Flat planes within tolerances specified.
   2) Lateral Alignment:
      a) Centerlines shall be within plus or minus 1/2-inch from dimensions shown.
      b) At intersections, centerlines shall intersect within plus or minus 1/2-inch of dimensions shown.
   3) Beam Type B-A:
      a) Physical Dimensions: Maximum 1/4-inch minus or 1/2-inch plus from dimension shown.
      b) Elevations: Within plus or minus 1/2-inch, except where tops of beams become part of finished slab. In this case refer to slab tolerances.
   4) Column Type C-A:
      a) Physical Dimensions: Maximum 1/4-inch minus or 1/2-inch plus from dimension shown.
      b) Plumb within 1/4-inch in 10 feet in all directions with maximum 1/2-inch out-of-plumb at top with respect to bottom.

3.03 FORM REMOVAL

A. Nonsupporting forms, sides of beams, walls, columns, and similar parts of Work, may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:

1. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
2. Curing and protection operations are maintained.

B. Elevated Structural Slabs or Beams: In accordance with ACI 318, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28-day compressive strength as determined by test cylinders.

C. Form Ties: Remove conical inserts and plug holes as specified in Section 03300, Cast-in-Place Concrete.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

END OF SPECTION

SECTION 03210
STEEL REINFORCEMENT

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

A. Unless otherwise specified, Work shall conform to requirements of ACI 301-20, Specifications for Concrete Construction.

B. Unless otherwise specified, requirements of this section shall comply with requirements for corresponding term in ACI 301.

C. Scope: In accordance with 3.1.1 Scope of ACI 301.

1.02 SUBMITTALS

A. Unless specified otherwise, in accordance with 3.1.2 Submittals of ACI 301.

B. Action Submittals:

1. Unless otherwise specified, comply with the following before fabrication and execution of Work:
   a. Placing Drawings: In accordance with 3.1.2.1(b) of ACI 301.
   b. Splices: In accordance with 3.1.2.1(c) of ACI 301.
   c. Column Dowels: In accordance with 3.1.2.1(e) of ACI 301.
   d. Field Bending or Straightening: In accordance with 3.1.2.1(f) of ACI 301.
   e. Field Cutting of Reinforcing Bars: In accordance with 3.1.2.1(h) of ACI 301.

C. Informational Submittals:

1. Reinforcement: In accordance with 3.1.2.1(a) of ACI 301.
2. Mechanical Splicing Systems:
   a. Data in accordance with 3.1.2.1(d) of ACI 301 and the following:
      1) Current ICC Evaluation Services Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
      2) Manufacturer’s written instructions for storage, handling, and installation.
3. Test results of field testing.

1.03 MATERIAL STORAGE AND HANDLING

A. In accordance with 3.1.3 Material storage and handling of ACI 301.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified, in accordance with 3.2.1 Materials of ACI 301 and the following:

1. Steel Reinforcing Bars: Unless otherwise specified, in accordance with 3.2.1.1 of ACI 301 and shall conform to ASTM A615/A615M, Grade 60. Unless otherwise specified in Contract Documents, steel reinforcing bars shall be deformed.
2. Reinforcement Supports and Spacers:
    a. In accordance with 3.2.1.8 of ACI 301 and the following:
        1) Plastic Protected Wire Bar Supports: In compliance with ANSI/CRSI – RB 4.1 Class 1 Reinforcement Supports, except provide Class 1A with epoxy-coated or dual-coated reinforcing steel.
        2) Stainless Steel Protected Wire Bar Supports: In compliance with ANSI/CRSI – RB 4.1 Class 2B Reinforcement Supports, except the non-stainless steel portion of the supports shall not extend closer than 3/4-inch from the surface of the concrete.
        3) Precast Cementitious Bar Supports and Spacers:
            a) In compliance with ANSI/CRSI – RB 4.1 Cementitious (Precast) Reinforcement Supports and the following:
                (1) Precast cementitious bar supports shall have equal or greater strength than the surrounding concrete.
                (2) Precast cementitious bar supports shall have water absorption and porosity equal to or less than water absorption and porosity of concrete being placed.
                (3) Precast cementitious bar supports shall be 4 square inches minimum, in plan.
                (4) Precast concrete shall contain a minimum of two tie embedded tie wires.
3. Tie Wire:
    a. Unless Otherwise Specified: Black, soft-annealed 16-gauge wire.
    b. Epoxy-Coated or Dual Coated Reinforcement: Tie wires coated with epoxy or other polymer.

c. Stainless Steel Reinforcement: Stainless steel or plastic-coated tie wires.

4. Mechanical Splices:
   a. In accordance with 3.2.1.9 of ACI 301 and following:
      1) Capable of developing reinforcing in tension or compression.
      2) Shall be configured such that concrete cover over coupler complies with specified minimum cover for steel reinforcement and maintains position of reinforcement within specified placement tolerances.

2.02 FABRICATION

A. Unless otherwise specified, fabrication shall be in accordance with 3.2.2 Fabrication of ACI 301.

B. Bending:

1. In accordance with 3.2.2.1 of ACI 301 and the following: Minimum inside bend diameters are specified in other Contract Documents.

PART 3 EXECUTION

3.01 PREPARATION

A. In accordance with 3.3.1 Preparation of ACI 301.

3.02 PLACING

A. Tolerances: Reinforcing Bars. In accordance with 3.3.2.1 of ACI 301.

B. Reinforcement Relocation: In accordance with 3.3.2.2 of ACI 301.

C. Concrete Cover: In accordance with requirements specified elsewhere in Contract Documents.

D. Tying Reinforcing Bars:

1. Unless otherwise specified, reinforcing bars shall be tied as required to maintain position of reinforcing bars within specified tolerances, after concrete has been placed.
2. Tie every other intersection on mats of reinforcing steel made up of No. 3 bars, No. 4 bars, No. 5 bars, and No. 6 bars.

E. Reinforcement Around Openings: Unless otherwise specified, provide one half the equivalent area of reinforcing bars interrupted by opening and penetration, on each side, above, and below openings and penetrations. Extend reinforcing bars lap length beyond opening at each end, which shall be calculated based on the minimum net spacing between typical and additional reinforcement.

F. Reinforcement Supports and Spacers:

1. Install reinforcement in accordance with 3.3.2.4 of ACI 301 and the following:
    a. Bar supports and spacers shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports, and location of reinforcement remains within tolerance throughout work.
    b. Bar supports and spacers in contact with waterproofing barrier or vapor barrier, shall not damage barrier system.
    c. Place reinforcement supported from ground on precast cementitious reinforcement supports.
    d. Bar Supports and Spacers in Contact with Forms: Unless otherwise specified, bar supports shall be plastic protected wire bar supports, stainless steel protected wire bar supports, or precast concrete bar supports.
        1) Unless otherwise specified, use Class 1 bar supports. Use Class 1A to support epoxy-coated and dual-coated reinforcing steel.
        2) Use stainless steel protected wire bar supports or precast concrete bar supports at formed surfaces that will be exposed to view in finished construction regardless of whether surface is specified to receive paint or coating.
        3) Use stainless steel protected wire bar supports or precast concrete bar supports at formed surfaces that will receive abrasive blasting, hydro-blasting, or grinding.

G. Dowels: In accordance with 3.3.2.6 of ACI 301.

H. Dowels: In accordance with 3.3.2.6 of ACI 301.

I. Lap Splices, Mechanical Splices, and Development of Reinforcement:

1. In accordance with 3.3.2.7 of ACI 301 and the following:
    a. Lap Splice Lengths and Development Lengths of Reinforcing Bars: Refer to other Contract Documents for additional information and requirements.

b. Stagger splices in adjacent bars where indicated.
c. Mechanical Splices:
1) Provide mechanical splices where shown on the Drawings.
2) Install assembly in accordance with manufacturer's written instructions and in accordance with ICC Evaluation Services Report or equivalent code agency report.

J. Field Bending or Straightening:

1. Unless otherwise specified, steel reinforcement shall not be field bent or straightened.
2. Where field bending and straightening is specified in the Contract Documents, field bending and straightening may be performed only once per reinforcing bar and shall be in accordance with 3.3.2.8 of ACI 301.

K. Field cutting reinforcement: In accordance with 3.3.2.9 of ACI 301.

L. Reinforcement through Movement Joints:

1. In accordance with 3.3.2.10 of ACI 301 and the following:
a. Movement joints include expansion joints and contraction joints.
b. Smooth dowels may continue through movement joints when unbonded on one side of joint.

M. Where reinforcement does not extend through a joint, terminate reinforcement 2 inches from face of joint.

3.03 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings. The Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

END OF SECTION

SECTION 03215
CONCRETE DOWELING

PART 1 GENERAL

1.01 DEFINITIONS

A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer’s catalog information.

B. Informational Submittals:

1. Manufacturer’s instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
2. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer’s name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer’s written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer’s instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2021 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze or thaw environments.
5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
7. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT-RE 500 V3 (ESR-3814) or HIT-HY 200 V3 (ESR-4868) Adhesive Anchors.
   b. DeWalt Anchors & Fasteners, Towson, MD; Power PURE110+ Epoxy Adhesive Anchor System (ESR-5144).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-3G Epoxy Adhesive Anchors (ESR-4057).

B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

C. Reinforcing Dowels: As specified in Section 03210, Steel Reinforcement.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes:
   a. Electric or pneumatic rotary type with medium or light impact.
   b. Hollow drills with flushing air systems are preferred.
2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.

C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.

D. Doweling:

1. Install per details shown on the Drawings and in accordance with adhesive manufacturer's instructions.
2. When using epoxy anchors, dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
3. Bent Bar Dowels: Where edge distances are critical and intersection with steel reinforcement or other obstruction is likely, slant drill to address edge distance or to clear obstruction. If drill must be slanted more than indicated in the manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

E. Adhesive:

1. Install in accordance with written manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.
3. Dispensing, Metering, and Mixing Adhesive Components: Use portable, automatic metering and mixing device or machine capable of maintaining prescribed mix ratio within deviation of 5 percent or less, by volume.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspection (Plan) on the Drawings. Contractor responsibilities and related information on special inspection and testing are included in Section 01451, Special Inspection, Observation, and Testing.

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01451, Special Inspection, Observation, and Testing.
2. Continuous inspection required where noted on the Drawings and where concrete dowels are installed in overhead applications.
3. Periodic inspection required where continuous inspection is not specified.
4. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report including the following:
   a. Product Description: Product name, rod diameter, and length.
   b. Drill bit compliance.

c. Hole diameter, diameter, and depth and cleanliness.
d. Adhesive expiration date.

5. Verification of dowel installation in accordance with manufacturer's published instructions.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

END OF SECTION

SECTION 03251
CONCRETE JOINTS AND ACCESSORIES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Waterstop: Details of splices, method of securing and supporting waterstop in forms to maintain proper orientation and location during concrete placement.
   b. Construction Joints: Layout and location for each type. Include joint locations shown on the Drawings, additional required joint locations, and any proposed alternate locations.
2. Product Data:
   a. Waterstops.
   b. Bond breaker.
   c. Premolded joint fillers.
   d. Roofing felt.
   e. Accessories not specified in other sections.

B. Informational Submittals:

1. Manufacturer’s written instructions for product shipment, storage, handling, installation or application, and repair for:
   a. Waterstops.
   b. Bond breaker.
   c. Bonding agent.
   d. Premolded joint fillers.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site: Verify delivered materials are in accordance with Specifications, regulatory agencies, and Manufacturer’s product data sheets prior to unloading and storing onsite.

B. Storage: Store materials under tarps to protect from oil, dirt, and sunlight or as required by Manufacturer.

PART 2 PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) WATERSTOP

A. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.

B. Specific Gravity: Approximately 1.37.

C. Shore Durometer Type A Hardness: Approximately 80.

D. Performance Requirements: COE Specification CRD-C-572.

E. Type Required in Expansion Joints: Where waterstop is indicated on the Drawings, provide 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center.

F. Type Required in Contraction and Control Joints: Where waterstop is indicated on the Drawings, provide 6 inches wide or 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center.

G. Type Required in Construction Joints: Where waterstop is indicated on the Drawings, provide flat ribbed, 6 inches wide or 9 inches wide with parallel longitudinal ribs or protrusions on each side of strip center. Center bulb is optional.

H. Corrugated or tapered type waterstops are not acceptable.

I. Thickness: Constant from bulb edge (or center of waterstop) to outside stop edge.

J. Minimum Weight per Foot of Waterstop:

1. 1.60 pounds for 3/8-inch by 6 inches.
2. 2.30 pounds for 3/8-inch by 9 inches.

K. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.

L. Manufacturers and Products for Center Bulb Type:

1. Use same manufacturers for flat ribbed profile:
   a. Vinylex Corp., St. Louis, MO; No. RB638H (6 inches by 3/8-inch) and No. RB938H (9 inches by 3/8-inch).
   b. Sika Corporation, Lyndhurst, NJ; Style 732 (6 inches by 3/8-inch) and Style 735 (9 inches by 3/8-inch).

c. Durajoint, Garrettsville, OH; Type 9 (6 inches by 3/8-inch), and Type 10 (9 inches by 3/8-inch).
d. JP Specialties, Inc., Murrieta, CA; PVC638 (6 inches by 3/8-inch ribbed center bulb), and PVC938 (9 inches by 3/8-inch).
e. BoMetals, Carrollton, GA; No. RCB-638LB (6 inches by 3/8-inch) and No. RCB-938NT (9 inches by 3/8-inch).
f. Dacon Plastics LLC, Jacksonville, TX; No. RCB17 (6 inches by 3/8-inch) and No. RCB18 (9 inches by 3/8-inch).

2.02 WIRE LOOPED PLASTIC WATERSTOP

A. Furnish as alternative to plastic waterstops.

B. Same material and geometry as plastic waterstops.

C. Furnish with continuous galvanized wire looping at edge for convenience in positioning and securing stop in place in forms.

D. Manufacturer and Product: Paul Murphy Plastics, Roseville, MI; “Wire Stop Waterstop;” geometry numbers ACR 6380, ACR 9380, as shown on the Paul Murphy Plastics Co. Drawing No. CCP-120-12M.

2.03 HYDROPHILIC WATERSTOP

A. For use at construction joints only, where new concrete is placed against existing concrete and as shown on the Drawings.

B. Material shall be a nonbentonite hydrophilic rubber compound.

C. Manufacturers and Products:

1. Sika Corporation, Lyndhurst, NJ; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
2. Adeka Ultra Seal, OCM Inc., Grayslake, IL; MC-2010M with 3M-2141 adhesive and P-201 sealant.
3. JP Specialties, Inc., Murrieta, CA; Type NB190 Profile A with Type NB190 Waterstop Paste and NB 190 Waterstop Adhesive sealant.

2.04 BOND BREAKER

A. Tape for Joints: Adhesive-backed glazed butyl or polyethylene tape. Same width as joint that will adhere to premolded joint material or concrete surface.

B. Use bond prevention material as specified in Section 03300, Cast-in-Place Concrete, except where bond breaker tape is specifically called for on the Drawings.

2.05 PREMOLDED JOINT FILLER

A. Bituminous Type: ASTM D994 or ASTM D1751.

B. Sponge Rubber:

1. Neoprene, closed cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 kPa to 168 kPa (17 pounds per square inch to 24 pounds per square inch) minimum. Use in joints for potable and nonpotable water containment structures.
2. Manufacturer and Product: Monmouth Rubber and Plastics, Corp, Long Branch, NJ; Durafoam DK5151.

2.06 ACCESSORIES

A. Joint Sealant: Polyurethane as specified in Section 07900, Joint Sealants.

B. One-Part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or Grade P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. BASF; Sonneborn, SL-1.
   b. Tremco; Vulkem 45.
   c. Sika Chemical Corp.; Sikaflex 1c SL.

C. Roofing Felt: ASTM D226, Type II, 30-pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.

D. Steel Reinforcement: As specified in Section 03210, Steel Reinforcement.

E. Nails: Galvanized, as required for securing premolded joint filler.

F. Ties for PVC Waterstop: “Hog Rings” or grommets for each edge at 12-inch maximum spacing.

PART 3 EXECUTION

3.01 GENERAL

A. Commence concrete placement after joint preparation is complete.

B. Time Between Concrete Pours: As specified in Section 03300, Cast-in-Place Concrete.

3.02 SURFACE PREPARATION

A. Construction Joints: Clean concrete surface prior to placement of abutting concrete.

1. Remove laitance and spillage from steel reinforcement and dowels.
2. Roughen surface to minimum of 1/4-inch amplitude:
   a. Sandblast after concrete has fully cured.
   b. Water blast after concrete has partially cured.
   c. Green cut fresh concrete with high-pressure water and hand tools.
3. If present in joint, do not damage waterstop.

B. Construction Joint with Hydrophilic Waterstop:

1. Follow hydrophilic waterstop manufacturer’s written instructions.
2. Concrete surface along which waterstop will be installed must be smooth, clean, and dry. Grind concrete as required.
3. Clean debris, dirt, dust, and foreign material from concrete and waterstop surfaces.

3.03 INSTALLATION OF WATERSTOPS

A. General:

1. Continuous waterstop shall be installed in all construction joints in walls and slabs of liquid-containing basins and channels and in walls of belowgrade structures, unless specifically noted otherwise.
2. Join waterstop at intersections to provide continuous seal.
3. Center waterstop on joint.
4. Secure waterstop in correct position. Tie waterstop to steel reinforcement using grommets, “Hog Rings,” or tiewire at maximum spacing of 12 inches. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.

7. Joints in Footings and Slabs:
    a. Ensure that space beneath horizontal waterstop is completely filled with concrete.
    b. During concrete placement, make visual inspection of waterstop area.
    c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift ribbed waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.

B. Plastic (PVC) Waterstops:

1. Install in accordance with manufacturer's written instructions.
2. Splice in accordance with waterstop manufacturer's written instructions using Teflon-coated thermostatically controlled heating iron at approximately 380 degrees F.
    a. Allow at least 10 minutes before new splice is pulled or strained in any way.
    b. Finished splices shall provide cross section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
    c. Use only factory made waterstop fabrications for all intersections, changes of directions and transitions.
    d. Field splice permitted only for straight butt welds.
    e. Edge welding not permitted.
    f. Additional splicing defects which are unacceptable and are cause for rejection:
        1) Misalignment of center bulbs and ribs greater than 1/16-inch or where waterstop cross-section is reduced by more than 15 percent.
        2) Charred or burnt material.
3. Wire looped plastic waterstop may be substituted for plastic waterstop.

C. Hydrophilic Waterstop:

1. Install in accordance with manufacturer's written instructions.
2. Provide minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of steel reinforcement, locate centered between layers of steel or as shown.
3. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
4. Lap ends of waterstop strip together at splices and corners and join with sealant.

5. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.
6. Lap hydrophilic waterstop 2 feet minimum with intersecting plastic waterstops.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

END OF SECTION

SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 GENERAL

A. Unless otherwise specified, Work must be in accordance with ACI 301, Specifications for Structural Concrete.

1.02 DEFINITIONS

A. Architectural Concrete: Concrete indicated as such in Contract Documents, and requires specified care in selection of concrete materials, forming, placing, and finishing to obtain desired architectural appearance.

B. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

C. Defective Area:

1. Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4-inch in diameter, cracks in liquid containment structures and belowgrade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures with visible leakage or that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections.
2. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.
3. Cold joints.

D. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained. Surfaces must be considered exposed concrete, even if covered by paint, sealers, or similar applications.

E. Flat and Elongated Particles of Aggregates: Those particles having a ratio of length to thickness greater than 5 to 1.

F. Hot Weather: As defined in ACI 305.1.

G. Hydraulic Structure: Liquid containment structure.

H. New Concrete: Less than 60 days old.

1.03 SUBMITTALS

A. Action Submittals:

1. Mix Designs:
   a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.
   b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
   c. Manufacturer's Certificate of Compliance, for the following:
      1) Portland cement.
      2) Blended cement.
      3) Fly ash.
      4) Slag cement.
      5) Aggregates, including specified class designation for coarse aggregate.
      6) Admixtures.
      7) Concrete producer has verified compatibility of constituent materials in design mix.
   d. Test Reports:
      1) Aggregates:
         a) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 2.
         b) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 4.
      2) Water-Soluble Chloride-Ion Content in Hardened Concrete:
         a) One of the following:
            (1) Test report in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
            (2) Calculation of water-soluble chloride content based on certified chloride content of each constituent material and proportion of constituent material in concrete mixture.
      3) Shrinkage Test Results: In accordance with ASTM C157/C157M as modified herein.
      4) Resistance to Alkali Silica Reaction: Supporting information for one of the options for mitigating alkali silica reaction listed in Article Concrete Mix Design. Include documentation of test results per applicable standards.

2. Product Data:
   a. Admixtures: Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.
   b. Specified ancillary materials.
3. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details must include, but not be limited to, the following:
   a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
   b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   c. Methods for temperature protection during placement.
   d. Types of covering, insulation, housing, or heating to be provided.
   e. Curing methods to be used during and following protection period.
   f. Use of strength accelerating admixtures.
   g. Methods for verification of in-place strength.
   h. Procedures for measuring and recording concrete temperatures.
   i. Procedures for preventing drying during dry, windy conditions.
4. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan must include, but not be limited to, the following:
   a. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   b. Use of retarding admixture.
   c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
   d. Types of shading and wind protection to be provided.
   e. Curing methods, including use of evaporation retardant.
   f. Procedures for measuring and recording concrete temperatures.
   g. Procedures for preventing drying during dry, windy conditions.

B. Informational Submittals:

1. Preinstallation conference minutes.
2. Manufacturer's application instructions for bonding agent.
3. Manufacturer's Certificate of Compliance to Specified Standards: Bonding agent.

4. Statement of Qualification:
    a. Batch Plant: Certification as specified herein.
    b. Mix designer.
    c. Installer.
    d. Testing agency.
5. Field test reports.
6. Liquid tightness test results.
7. Concrete Delivery Tickets:
    a. For each batch of concrete before unloading at Site.
    b. In accordance with ASTM C94/C94M, including requirements 14.2.1 through requirements 14.2.10.
    c. Indicate amount of mixing water withheld and maximum amount that is permitted to be added at Site.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Batch Plant: National Ready Mixed Concrete Association (NRMCA) Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or Department of Transportation (DOT)-certified mix designer in jurisdiction of the Work. Requirement may be waived if Mix Designer is a professional engineer registered in the state where the Project is located.
3. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
    a. Where field testing is required of Contractor, personnel conducting field tests must be qualified as ACI Concrete Field-Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
    b. Personnel performing laboratory tests must be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor must be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

B. Preinstallation Conference:

1. Required Meeting Attendees:
   a. The Contractor, including pumping, placing, and finishing, and curing subcontractors.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Steel reinforcement installer.
   e. Testing and sampling personnel.
   f. The Owner and/or the Owner's designee.
2. Schedule and conduct Preinstallation Conference prior to incorporation of respective products into Project. Notify the Owner of location and time.
3. Agenda must include:
   a. Admixture types, dosage, performance, and redosing at Site.
   b. Mix designs, test of mixes, and Submittals.
   c. Placement methods, techniques, equipment, consolidation, and form pressures.
   d. Slump and placement time to maintain slump.
   e. Finish, curing, and water retention.
   f. Steel reinforcement details.
   g. Protection procedures for weather conditions.
   h. Other specified requirements requiring coordination.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, Work must be in accordance with ACI 301.

2.02 MATERIALS

A. Cementitious Materials:

1. Cement:
   a. Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
   b. Blended Hydraulic Cement: Type IL, MS, conforming to ASTM C595/C595M.
   c. Furnish from one source.
2. Supplementary Cementitious Materials (SCM):
   a. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
      1) When air-entrainment is specified, fly ash shall comply with uniformity requirements of Table 3 of ASTM C618.

b. Slag Cement: In accordance with ASTM C989/C989M, Grade 100 or Grade 120.
c. Silica Fume: In accordance with ASTM C1240.

B. Aggregates: Unless otherwise permitted, furnish from one quarry location for each aggregate type used in a mix design.

1. Aggregates:
   a. In accordance with ACI 301, except as modified herein.
   b. Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
   c. Aggregates that are susceptible to alkali-carbonate reactions shall not be used.
   d. Resistance to Alkali Silica Reaction: See Article Concrete Mix Design.
2. Fine Aggregates:
   a. In accordance with ACI 301, except as modified herein.
   b. In the event manufactured sand is included in mix design, material must be from same source as coarse aggregate.
   c. Limit deleterious substances in accordance with ASTM C33/C33M, Table 2 and as follows:
      1) Limit material finer than 75-µm (No. 200) sieve to 5 percent mass of total sample.
      2) Limit coal and lignite to 1.0 percent.
3. Coarse Aggregate:
   a. Crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles as determined by ASTM D4791.
   b. Class designation in accordance with ASTM C33/C33M, Table 4: 4S unless otherwise specified.
   c. Limit deleterious substances in accordance with ASTM C33/C33M, Table 4 for specified class designation.

C. Admixtures:

1. Characteristics:
   a. Compatible with other constituents in mix.
   b. Contain at most, only trace amount chlorides in solution.
   c. Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
   d. Do not use calcium chloride admixtures.
2. Air-entraining Admixture: ASTM C260/C260M.
3. Water-reducing Admixture: ASTM C494/C494M, Type A or Type D.
4. Retarding Admixture: ASTM C494/C494M, Type B.
5. Accelerating Admixture: ASTM C494/C494M, Type C.

6. Do not use calcium chloride as an admixture.
7. High Range Water-reducing Admixture: ASTM C494/C494M, Type F or Type G.
8. Viscosity Modifying Admixture (VMA): ASTM C494/C494M, Type S.
9. Corrosion Inhibiting Admixtures: ASTM C1582/C1582M.

D. Water and Ice: Mixing water for concrete and water used to make ice must be potable water unless alternative sources of water are permitted.

1. Water from alternative sources must comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water must be less than:
   a. Chloride Content: 1,000 ppm.
   b. Sulfate Content as SO_4: 3,000 ppm.
   c. Alkalis as (Na_2O + 0.658 K_2O): 600 ppm.
   d. Total Solids by Mass: Less than 50,000 ppm.

2.03 ANCILLARY MATERIALS

A. Bonding Agent:

1. Unless otherwise specified, in accordance with the following:
   a. ASTM C881/C881M, Type V.
   b. Two-component, moisture insensitive, 100 percent solids epoxy.
   c. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.

B. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
   a. Dayton Superior Corporation, Miamisburg, OH; Sure Lift J6WB.
   b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

C. Repair Material:

1. In accordance with requirements of Section 03720, Repair of Vertical and Overhead Concrete Surfaces.
2. In accordance with requirements of Section 03722, Repair of Horizontal Concrete Surfaces.

D. Structural Non-Moving Crack Repair: In accordance with requirements of Section 03740, Epoxy Resin Injection Grouting.

2.04 CONCRETE MIX DESIGN

A. General:

1. See supplement at end of this section for mix design requirements for each class of concrete used on Project.
2. Unless otherwise specified, prepare design mixtures for each type and strength of concrete, in accordance with requirements of ACI 301.
3. Unless specified otherwise, selection of constituent materials and products in mix design are optional.
4. Use water-reducing admixture or water-reducing admixture and high-range water-reducing admixture for the following:
   a. Concrete mixtures that will be pumped.
   b. Concrete mixtures with a water-cementitious materials ratio below 0.50.
   c. Concrete mixtures used in elements of a liquid-containment structure.
   d. Concrete mixtures used in columns, piers, pilasters, and walls.
   e. When needed to achieve fresh properties that facilitate handling, placing, and consolidating of concrete mixtures, and to achieve specified hardened properties.
   f. When anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.
5. Unless otherwise specified, desired fresh properties of concrete must be determined by Contractor and coordinated with concrete producer. Fresh properties of concrete must remain stable to satisfaction of Contractor, for duration of placement and consolidation, and must remain in conformance with requirements of Contract Documents.
6. Concrete producer is encouraged to employ environmentally sustainable concrete mix design technologies such as supplementary cementitious materials and aggregate packing.

B. Proportions:

1. Concrete mixtures must meet specified aesthetic, durability, and strength requirements.
2. Where fly ash is included in mix, minimum fly ash content shall be 15 percent of weight of total cementitious materials.
3. Where silica fume is included in mix, minimum silica fume content shall be 5 percent of weight of total cementitious materials.

C. Resistance to Alkali-Silica Reaction:

1. Unless otherwise specified, or unless members are designated as being dry in service and not in contact with ground, or assigned to Exposure Class W0, use one of the three following options for qualifying concrete mixtures to reduce potential of alkali-silica reaction.
   a. For each aggregate used in concrete, expansion result determined in accordance with ASTM C1293 must not exceed 0.04 percent at 1-year.
   b. For each aggregate used in concrete, expansion result of aggregate and cementitious materials combination determined in accordance with ASTM C1567 must not exceed 0.10 percent at age of 16 days. Submit supporting data for each aggregate showing expansion in excess of 0.10 percent at 16 days when tested in accordance with ASTM C1260.
   c. Alkali content in concrete (LBA), excluding that from supplementary cementitious materials and the pozzolans and slags in blended cements, must not exceed 4 lb/yd^3 for aggregates with expansions more than or equal to 0.04 percent and less than 0.12 percent or 3 lb/yd^3 for aggregates with expansions greater than or equal to 0.12 percent and less than 0.24 percent. Reactivity must be determined by testing in accordance with ASTM C1293. Alkali content must be calculated as follows:
      1) LBA = (cement content, lb/yd^3) × (equivalent alkali content of portland cement in percent/100 percent).
2. Option 1.c. shall not be used with natural pozzolan or fly ash that has a CaO content greater than 18 percent, or for aggregate with expansion at 1-year greater than or equal to 0.24 percent when tested in accordance with ASTM C1293.
3. Fly ash with an alkali content greater than 4 percent shall not be used in Option 1.b. or Option 1.c.

D. Concrete Shrinkage Limits:

1. If shrinkage limits are specified, design mix for the following shrinkage limits and test in accordance with ASTM C157/C157M, with the following modifications:
   a. Prisms shall have 4-inch square cross-section.
   b. Prisms must be moist cured for 7 days prior to 28-day drying period.
   c. Comparator reading at end of 7-day moist cure must be used as initial length in length change calculation.
   d. Reported results must be average of three prisms.

e. If shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.

2. Results at end of 28-day drying period shall not exceed 0.040 percent.

E. Slump:

1. Unless otherwise specified, select a target slump at point of delivery for concrete mixtures used for Work. Selected target slump shall not exceed 9 inches.
2. Concrete shall not show visible signs of segregation.
3. Target slump indicated on submittal shall be used as basis for acceptance during the Project.
4. Determine slump by ASTM C143/C143M.
5. Slump tolerances shall be in accordance with ACI 117.

F. Size of Coarse Aggregate:

1. Unless otherwise specified, nominal maximum size of coarse aggregate shall not exceed:
   a. Three-fourths of minimum clear spacing between reinforcement.
   b. One-fifth of narrowest dimension between sides of forms.
   c. One-third of thickness of slabs or toppings.
2. Architectural concrete with Type W-10, Fractured Fin Finish: 3/4-inch maximum size aggregate.

G. Combined Aggregate Gradation:

1. Combined Gradation Limits: Fine aggregate must be in range of 36 percent to 40 percent of total aggregate weight.

2.05 CONCRETE MIXING

A. General: Unless otherwise specified, in accordance with ACI 301.

B. Temperature Limits: Maintain concrete temperature below 95 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.

2.06 SOURCE QUALITY CONTROL

A. Source Quality Control Inspection: Engineer must have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

PART 3 EXECUTION

3.01 GENERAL

A. Unless otherwise specified, in accordance with ACI 301.

3.02 PREPARATION

A. Preparation: In accordance with ACI 301.

B. Inspection: Notify Engineer and Special Inspector at least 1 full working day in advance before starting to place concrete.

3.03 CONCRETE BONDING

A. Construction Joints in New Concrete Members: Prepare surface of construction joint as specified in Section 03251, Concrete Joints and Accessories.

B. Construction Joints at Existing Concrete:

1. Thoroughly clean and mechanically roughen existing concrete surfaces to a roughness profile range between CSP 7 to CSP 9 when verified by comparison to PC1-10.
2. Saturate surface with water for 24 hours prior to placing new concrete.

3.04 PLACEMENT OF CONCRETE

A. Unless otherwise specified, in accordance with ACI 301.

B. Retempering: Not permitted for concrete where cement has partially hydrated.

C. Pumping of Concrete: Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.

D. Joints in Footings and Slabs with Waterstops (Excluding Hydrophilic and Injection-Type): Verify space beneath plastic waterstop completely fills with concrete and is consolidated along entire length of waterstop.

E. Maximum Size of Concrete Placements:

1. Locate expansion, control, and contraction joints where shown on the Drawings.
2. Construction Joints: Locate additional construction joints as follows:
   a. Where approved in joint location submittal required in Section 03251, Concrete Joints and Accessories.
   b. Provide vertical construction joints in walls at maximum spacing of 40 feet, unless shown or approved otherwise.
3. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

3.05 CURING

A. In accordance with Section 03370, Concrete Curing, unless otherwise specified.

3.06 REPAIRING CONCRETE

A. General:

1. Repair defective areas of concrete.
2. Repair horizontal concrete surfaces in accordance with Section 03722, Repair of Horizontal Concrete Surfaces.
3. Repair vertical and overhead concrete surfaces in accordance with Section 03720, Repair of Vertical and Overhead Concrete Surfaces.
4. Unless otherwise specified, cracks which meet definition of defective area must be repaired by injecting epoxy resin as specified in Section 03740, Epoxy Resin Injection Grouting.
5. Moving cracks deemed as nonstructural by Owner must be repaired by injecting polyurethane resin as specified in Section 03744, Polyurethane Injection Grouting.
6. Develop repair techniques with material manufacturer on surface that will not be visible in final construction prior to starting actual repair work and show how finish color will blend with adjacent surfaces. Obtain approval from Owner.
7. Obtain quantities of repair material and manufacturer’s detailed instructions for use to provide repair with finish to match adjacent surface or apply enough repair material adjacent to repair to blend finish appearance.
8. Repair of concrete must provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Owner.

B. Tie Holes:

1. Unless otherwise specified, fill with specified repair material.
   a. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.

C. Exposed Metal Objects:

1. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1-inch and then cutting or removing metal object.
2. Repair area of chipped-out concrete as specified for defective areas.

D. Blockouts at Pipes or Other Penetrations: Where shown install in accordance with requirements of the Drawings.

3.07 FORMED SURFACE FINISHES

A. Concrete Walls Finishes:

1. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.
2. Type W-1 (Ordinary Wall Finish):
   a. Patch tie holes.
   b. Remove projections.
   c. Repair defective areas to provide smooth uniform appearance.
   d. Inject cracks.
3. Type W-2 (Smooth Wall Finish):
   a. Patch tie holes.
   b. Remove projections.
   c. Repair defective areas to provide smooth uniform appearance.
   d. Inject cracks.

3.08 CONCRETE SLAB FINISHES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
2. Do not use "jitterbugs" or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
3. Finish slab in accordance with specified slab finish.
4. Do not dust surfaces with dry materials nor add water to surfaces.
5. Cure concrete as specified in Section 03370, Concrete Curing.

B. Type S-1 (Steel Troweled Finish):

1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation.
2. Wood float to true, even plane with no coarse aggregate visible.
3. Use enough pressure on wood floats to bring moisture to surface.
4. After surface moisture has disappeared, hand steel trowel concrete to produce smooth, smooth dense surface, free from trowel marks.
5. Provide light steel-troweled finish (two trowelings) at air-entrained slabs. Provide hard steel-troweled finish (ringing sound from the trowel) for non-air entrained slabs.
6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.
7. Power Finishing:
    a. Approved power machine may be used in lieu of or in addition to hand finishing in accordance with directions of machine manufacturer.
    b. Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high spots and low spots in slab.
    c. Do first steel troweling for slab S-1 finish by hand.

C. Type S-2 (Wood Float Finish):

1. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.
2. Wood float finish to compact and seal surface.
3. Remove laitance and leave surface clean.
4. Coordinate with other finish procedures.

D. Type S-3 (Underside Elevated Slab Finish):

1. When forming is removed, grind off projections on underside of slab and repair defective areas, including small shallow air pockets where schedule of concrete finishes requires:
    a. Prepare surfaces to match Type W-2 (Smooth Wall Finish).

E. Type S-5 (Broomed Finish):

1. Finish as specified for Type S-1 floor finish, except use only a light-steel troweled finish, and then finish surface by drawing fine-hair broom lightly across surface.
2. Broom in same direction and parallel to expansion joints, or, in case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.

F. Type S-6 (Sidewalk Finish):

1. Slope walks down 1/8-inch per foot away from structures, unless otherwise shown.
2. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
3. Broom surface at right angles to direction of traffic or as shown.
4. Lay out sidewalk surfaces in blocks, as shown or as directed by Engineer, with grooving tool.

G. Concrete Curbs:

1. Float top surface of curb smooth and finish all discontinuous edges with steel edger.
2. After concrete has taken its initial set, remove front form and give exposed vertical surface an ordinary wall finish, Type W-1.

3.09 CONCRETE SLAB TOLERANCES

A. General: Deviation from elevation for top surface of base slab, base mat, foundation slab, or foundations that is integral with any previously listed elements of a hydraulic structure, shall be in accordance with ACI 117 tolerances for a slab-on-ground, for cast-in-place concrete building.

B. Slab Tolerances:

1. Slab tolerances must be in accordance with the following floor surface classifications as shown in Table 4.8.6.1 of ACI 117:
   a. Slab Type S-A:
      1) Floor Surface Classification: Moderately flat.
   b. Slab Type S-B:
      1) Floor Surface Classification: Flat.
2. Slab Elevation and Thickness:
   a. Finish Slab Elevation: Slope slabs to floor drains and gutter. Slabs must adequately drain regardless of tolerances.
   b. Thickness: Maximum 1/4-inch minus or 1/2-inch plus from thickness shown.

3.10 BACKFILL AGAINST STRUCTURES

A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.

B. Refer to General Structural Notes on the Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.

C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.11 FIELD QUALITY CONTROL

A. General:

1. Unless otherwise specified, concrete field-testing services will be in accordance with ACI 301 and Section 01451, Special Inspection, Observation, and Testing.
2. Unless otherwise specified, refer to ACI 301 and Section 01451, Special Inspection, Observation, and Testing for additional information regarding requirements related to concrete field quality assurance.
3. Employ one or more agencies to provide tests for concrete work during construction, as specified herein and in Section 01451, Special Inspection, Observation, and Testing.
4. Agencies shall be objective, competent, and independent from the Contractor responsible for the Work being inspected.
5. Identify agencies to building official, for building official's approval.
6. Agencies shall disclose to building official and registered design professional in responsible charge possible conflicts of interest so that objectivity can be confirmed.
7. Provide electrical and water services to area of site for safe storage and curing of concrete test specimens prior to transport of test specimens to testing lab.
8. Concrete testing agency will provide storage facility for proper curing of concrete test specimens onsite prior to transport of test specimens to testing lab.
9. Unless otherwise specified, concrete will be sampled for making test specimens, from point of delivery.
10. For additional information regarding requirements of the Contractor related to concrete field quality assurance, refer to Section 01451, Special Inspection, Observation, and Testing.
11. Unless otherwise specified, sampled concrete used to mold strength test specimens (ASTM C31/C31M) will be tested for slump (ASTM C143/C143M) or slump flow (ASTM C1611/C1611M), air content (ASTM C231/C231M), temperature (ASTM C1064/C1064M), and density (ASTM C138/C138M).

12. Measured Air Content at Point of Delivery:
    a. When measured air content at point of delivery is greater than specified limit, a check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents.
    b. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents.
    c. Concrete that has failed to meet requirements of Contract Documents must be rejected.
13. If concrete is pumped, concrete will be sampled for air content testing at point of delivery.
    a. For each concrete mixture that will be pumped, once.
14. Test specimens must be stored and cured in accordance with ASTM C31/C31M and tested in accordance with ASTM C39/C39M.
15. Frequency of testing may be changed at discretion of Special Inspector or Owner.
16. Evaluation and acceptance will be in accordance with ACI 301 and the Contract Documents.

B. Concrete Strength Test:

1. Unless otherwise specified, specimens will be made and tested as follows:
    a. One standard test specimen at age of 7 days for information.
    b. Minimum of two standard test specimens at age of 28 days for acceptance.
    c. A minimum of one spare standard test specimen per sample.
2. Spare cylinder will be tested as directed by Owner.

C. Tolerances:

1. Concrete tolerances must comply with the more stringent of equipment manufacturers' tolerances and specified tolerances.
2. Formed Surfaces:
    a. Formed surface finishes must comply with specified requirements.
    b. Tolerances of formed surfaces must comply with specified requirements and with ACI 117 for cast-in-place concrete buildings.

3. Unformed Surfaces:
    a. Surface finishes must comply with specified requirements.
    b. Unless otherwise specified, tolerances for unformed surface must conform to requirements of ACI 117 for cast in place concrete buildings.
    c. Concrete slab tolerances must comply with specified requirements and with ACI 117 random traffic floor surface finish tolerances.
    d. Slab Elevation:
        1) Slabs must slope to drains.
        2) Top of concrete elevations must comply with specified requirements and ACI 117 for cast-in-place concrete buildings.
    e. Slab thickness tolerance must comply with specified requirements and ACI 117 for cast in place concrete buildings.

D. Liquid Tightness Tests:

1. Purpose: To determine integrity and liquid-tightness of finished exterior and interior concrete surfaces of liquid containment structures.
2. Contractor shall conduct liquid tightness testing.
3. Structures shall be filled with test water only after the following conditions are satisfied:
    a. Strength of concrete in walls of containment structure has attained specified 28-day compressive strength.
    b. Concrete slab(s) that brace top of containment walls (if any) are complete, and strength of concrete in those slab(s) has attained specified 28-day compressive strength.
4. Water for initial tightness test will be provided by Owner.
    a. Water source will be the Owner.
    b. Provide means to transport water to structure to be tested.
    c. If additional tightness tests are required because of failure to meet criteria, provide water for subsequent tests.
5. After testing has been completed, dispose of test water in a manner approved by Owner.
6. Liquid-Tightness Test Requirement:
    a. Perform tightness tests in accordance with ACI 350.1 and as specified herein.
    b. Do not place backfill or install brick facing, topping slab, coatings, or other work that will cover concrete surfaces until tightness testing has been completed and approved.
    c. Measure evaporation, precipitation, and temperature as specified.
7. Measure water surface at two points 180 degrees apart when possible where attachments, such as ladders, exist at 24-hour intervals.

8. Acceptance Criteria:
    a. Acceptance of containment structure must be based on criteria for both Part 1 and Part 2. Containment structures must be retested until compliance is achieved.
    b. Part 1, Qualitative: If moisture is observed on containment structure surfaces, exterior to contained liquid, where moisture can be picked up on a dry hand, containment structure is noncompliant.
    c. Part 2, Quantitative:
        1) Volume loss must not exceed 0.050 percent of contained liquid volume per 24-hour period, adjusted for evaporation, precipitation, and temperature.
        2) Acceptance that structure has passed Part 2 of tightness test must be based on total volume loss at end of specified test period.
9. Repairs when test fails:
    a. Dewater structure. Fill leaking cracks with crack repair epoxy as specified in Section 03740, Epoxy Resin Injection Grouting.
    b. Patch areas of damp spots previously recorded and repeat water leakage test in its entirety until structure successfully passes test.

3.12 MANUFACTURER'S SERVICES

A. Provide representative at Site in accordance with Section 01640, Manufacturers' Services and Training, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.

1. Concrete Producer Representative:
    a. Be present during first placement of each type of concrete mix.
    b. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
    c. Establish control limits on concrete mix designs.
    d. Provide equipment for control of concrete redosing for air entrainment or high range water reducing admixture, superplasticizers, at Site to maintain proper slump and air content if needed.

3.13 PROTECTION OF INSTALLED WORK

A. After curing as specified in Section 03370, Concrete Curing, and after applying final floor finish, cover slabs with plywood or particle board or plastic sheeting or other material to keep floor clean and protect it from material and damage because of other construction work.

B. Repair areas damaged by construction, using specified repair materials and approved repair methods.

3.14 SCHEDULE OF CONCRETE FINISHES

A. Form Tolerances: As specified in Section 03100, Concrete Forming and Accessories.

B. Unless otherwise specified, provide concrete finishes and tolerances as scheduled:

Area	Type of Finish	Required Tolerances
Exterior Wall Surfaces		
Abovegrade/exposed (above point 6" below finish grade)	W-2	W-B
Abovegrade/covered with brick veneer or other finish material	W-1	W-A
Backfilled/waterproofed (below point 6" below finish grade)	W-1	W-A
Backfilled/not waterproofed (below point 6" below final grade)	W-1	W-A
Interior Wall Surfaces		
Covered hydraulic structures not painted or coated	W-1	W-A

Exterior Slabs		
Roof slab/exposed	S-5	S-B
Roof slab/covered with roofing material	S-1	S-A
Top of footing	S-2	S-A
Slabs in hydraulic structures unless otherwise specified	S-1	S-A
Stairs and landings	S-5	S-B
Sidewalks	S-6	S-B
Exterior slabs unless otherwise specified	S-5	S-A
Interior Slabs		
Underside of elevated slabs	S-3	S-A

3.15 SUPPLEMENTS

A. Requirements of concrete mix designs (CMD) following "End of Section," are a part of this specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, CMD-1.
2. Concrete Mix Design, CMD-2.
3. Concrete Mix Design, CMD-3.

END OF SECTION

CONCRETE MIX DESIGN, CMD-1

A. Mix Locations: Typical, unless otherwise specified.

B. Exposure Categories and Classifications: F3S1W2C2 as defined in ACI 318-19.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
2. Minimum concrete compressive strength (f'c) must be 5,000 pounds per square inch at 28 days.
3. Concrete mix must be designed to conform to shrinkage limits.
4. Air-entraining admixtures are prohibited in concrete mixtures and total air content must not be greater than 3 percent, for the following:
   a. Slabs to receive a hard-troweled finish.
5. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
3/8	7.5
1/2	7.0
3/4	6.0
1	6.0
1-1/2	5.5

‡ See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.
* Tolerance of air content is ±1-1/2 percent.
§ Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on sieved fraction passing 1-1/2-inch sieve in accordance with ASTM C231/C231M.

6. Limit supplementary cementitious materials as follows:

Limits on Cementitious Materials for Concrete Assigned to Exposure Class F3‡*	
Supplementary Cementitious Materials	**Maximum Percent of Total Cementitious Materials by Mass**
Fly ash or natural pozzolans conforming to ASTM C618	25
Slag cement conforming to ASTM C989	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or natural pozzolans and silica fume	35
Total of fly ash or natural pozzolans, slag cement, and silica fume	50

‡Supplementary cementitious materials, including fly ash and natural pozzolans, slag cement, and silica fume, used in the manufacture of ASTM C595/C595M and ASTM C1157/C1157M blended cements shall be included in assessing compliance with these limits.

*Individual limits shall apply regardless of the number of cementitious materials in a concrete mixture.

7. Provide cementitious materials in accordance with one of the following:
   a. ASTM C595 Type IL, MS, moderate sulfate resistance. Mixes containing ASTM C595 IL cementitious materials shall include a corrosion inhibiting admixture.
   b. ASTM C150/C150M Type II or Type V; inclusion of supplementary cementitious materials in design mix is optional.
   c. ASTM C150/C150M types other than Type II or Type V in accordance with the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
   d. ASTM C595/C595M Types excluding Type IS (greater than 70), conforming to ASTM C595/C595M and having (MS) designation.
   e. ASTM C1157/C1157M having (MS) designation.
8. Limit water-soluble, chloride ion content in hardened concrete, percent by mass of cementitious materials to 0.10.
   a. Limits are stated in terms of water-soluble chloride ions (Cl^-) in percent by mass of cementitious materials.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CMD-2

A. Mix Locations:

1. Provide this concrete mix for the following elements:
   a. Electrical duct banks.
   b. Pipe encasements that are not cast monolithically with concrete base mats or slabs.
   c. Where specified in Contract Documents.

B. Exposure Categories and Classifications: F1S1W0C1 as defined in ACI 318-19.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.50.
2. Minimum concrete compressive strength (f’c) must be 3,500 pounds per square inch at 28 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content must not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
   b. Slabs to receive dry shake floor hardener.
   c. Slabs to receive topping placed monolithically as two-course floor on top of plastic concrete.

4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
3/8	6.0
1/2	5.5
3/4	5.0
1	4.5
1-1/2	4.5
2§	4.0
3§	3.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is ±1-1/2 percent.

§Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.

5. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II or Type V; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II or Type V in accordance with the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
   c. ASTM C595/C595M Types excluding Type IS (greater than 70), conforming to ASTM C595/C595M and having (MS) designation.
   d. ASTM C1157/C1157M having (MS) designation.
6. Limit water-soluble, chloride ion content in hardened concrete, percent by mass of cementitious materials to 0.30.
   a. Limits are stated in terms of water-soluble chloride ions (Cl^-) in percent by mass of cementitious materials.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CMD-3

A. Mix Locations: Concrete curbs, sidewalks, valley gutters, and transition curbs.

B. Exposure Categories and Classifications: F3S1W1C2 as defined in ACI 318-19.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
2. Minimum concrete compressive strength (f'c) must be 4,500 pounds per square inch at 28 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content must not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
   b. Slabs to receive dry shake floor hardener.
4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
3/8	7.5
1/2	7.0
3/4	6.0
1	6.0
1-1/2	5.5

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
2§	5.0
3§	4.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is ±1-1/2 percent.

§Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.

5. Limit supplementary cementitious materials as follows:

Limits on Cementitious Materials for Concrete Assigned to Exposure Class F3 ‡*	
Supplementary Cementitious Materials	**Maximum Percent of Total Cementitious Materials by Mass**
Fly ash or natural pozzolans conforming to ASTM C618	25
Slag cement conforming to ASTM C989	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or natural pozzolans and silica fume	35
Total of fly ash or natural pozzolans, slag cement, and silica fume	50

‡ Supplementary cementitious materials, including fly ash and natural pozzolans, silica fume, and slag cement, used in the manufacture of ASTM C595/C595M and ASTM C1157/C1157M blended cements shall be included in assessing compliance with these limits.

*Individual limits shall apply regardless of the number of cementitious materials in concrete mixtures.

6. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II or Type V; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II or Type V in accordance with the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
   c. ASTM C595/C595M Types excluding Type IS (greater than 70), conforming to ASTM C595/C595M and having (MS) designation.
   d. ASTM C1157/C1157M having (MS) designation.
7. Limit water-soluble, chloride ion content in hardened concrete, percent by mass of cementitious materials to 0.30.
   a. Limits are stated in terms of water-soluble chloride ions (Cl^-) in percent by mass of cementitious materials.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

SECTION 03370
CONCRETE CURING

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Manufacturers' data indicating compliance with the requirements specified herein for the following products:
   a. Exposed aggregate finish retardant on formed surface.
   b. Evaporation retardant.
   c. Curing compound.
   d. Penetrating water repellent sealer.
   e. Clear liquid densifier.
2. Curing methods proposed for each type of element such as slab, walls, beams, and columns in each facility.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements, for the following:
   a. Curing compound showing moisture retention requirements.
   b. Retardants for exposed aggregate finish.

PART 2 PRODUCTS

2.01 MATERIALS

A. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315Type I, Class A.
2. Manufacturers and Products:
   a. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
   b. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
   c. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
   d. Dayton Superior; Safe Cure and Seal 1315 EF.
   e. BASF Construction Chemicals., Shakopee, MN; MasterKure CC 200WB.
   f. Euclid Chemical Co., Cleveland, OH; EucoCure VOX.
   g. Euclid Chemical Co., Cleveland, OH; Kurez VOX White Pigmented.

B. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; MasterKure ER 50.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

C. Water: Clean and potable, containing less than 500 ppm of chlorides.

PART 3 EXECUTION

3.01 CONCRETE CURING

A. General:

1. Cure all concrete in accordance with project specifications and ACI308.1.
2. Where surfaces are to receive coatings, painting, cementitious material, or other similar finishes, use only water curing procedures. Refer to Interior Finish Schedule for surfaces to receive coatings.
3. Use only water curing on potable water structures.
4. Where curing compound cannot be used, water curing as described below or special methods using moisture shall be agreed upon by Engineer prior to placing concrete.
5. As required in Section 03300, Cast-in-Place Concrete, if result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified below, by 7 additional days.

B. Use one of the following methods as approved by Engineer:

1. Vertical Surfaces:
   a. Method 1: Leave concrete forms in place and keep surfaces of forms and concrete wet for 7 days.
   b. Method 2: Continuously sprinkle with water 100 percent of exposed surfaces for 7 days starting immediately after removal of forms.
   c. Method 3: Apply curing compound, where allowed, immediately after removal of forms.
2. Horizontal Surfaces:
   a. Method 1: Protect surface by water ponding for 7 days. Use Method 1 on foundation slabs.
   b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.

c. Method 3: Continuously sprinkle exposed surface for 7 days.
d. Method 4: Apply curing compound, where allowed, immediately after final finishing when surface will no longer be damaged by traffic.

END OF SECTION

SECTION 03600
GROUTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Product data of grouts.
2. Proposed method for keeping existing concrete surfaces wet prior to placing nonshrink grout.
3. Forming method for fluid grout placements.
4. Curing method for grout.

B. Informational Submittals:

1. Manufacturer’s Written Instructions: Mixing of grout.
2. Test Reports:
   a. Test report for 24-hour evaluation of nonshrink grout.
   b. Test results and service report from demonstration and training session.
   c. Field test reports and laboratory test results for field-drawn Samples.

1.02 QUALIFICATIONS

A. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Nonshrink Grout Test Form, attached at the end of this section. Provide independent testing laboratory test results for testing conducted within last 18 months.

PART 2 PRODUCTS

2.01 NONSHRINK GROUT AND EPOXY GROUT SCHEDULE

A. Furnish nonshrink grout (Category I, Category II, and Category III) and epoxy grout for applications as indicated in the following schedule:

Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Blockouts for gate guides	I or II		II
Column baseplates single-story	I or II		II
Machine bases 25 hp or less	II	II	II
Baseplates for columns over one story	II	II	II
Baseplates for legs of tanks, pipe supports, nonvibratory equipment	II	II	II
Form Tie-Through bolt openings	II	II	II
Machine bases 26 hp and up	III or Epoxy Grout	III or Epoxy Grout	III or Epoxy Grout
Baseplates and/or soleplates with vibration, thermal movement, etc.	III or Epoxy Grout	III or Epoxy Grout	III or Epoxy Grout

2.02 NONSHRINK GROUT

A. Category I:

1. Nonmetallic and nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in accordance with ASTM C1107/C1107M:
   a. Grout shall have flowable consistency.
   b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.

5. Minimum strength of flowable grout, 3,000 pounds per square inch at 3 days, 5,000 pounds per square inch at 7 days, and 7,000 pounds per square inch at 28 days.
6. Manufacturers and Products:
    a. Master Builders Solutions, Shakopee, MN; MasterFlow 100.
    b. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.
    c. US MIX Co., Denver, CO; US SPEC GP Grout.
    d. Five Star Products Inc., Fairfield, CT; Five Star Grout.

B. Category II:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
    a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
    b. Temperatures of 40 degrees F, 80 degrees F, and 90 degrees F.
5. One hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 pounds per square inch at 1-day, 4,500 pounds per square inch at 3 days, and 7,500 pounds per square inch at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturers and Products:
    a. Master Builders Solutions, Shakopee, MN; MasterFlow 928.
    b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
    c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
    d. Dayton Superior Corp., Miamisburg, OH; Sure-Grip High Performance Grout.
    e. US MIX Co., Denver, CO; US SPEC MP Grout.

C. Category III:

1. Metallic and nongas-liberating.
2. Prepackaged aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
    a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
    b. Temperatures of 40 degrees F and 100 degrees F.

5. One hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 4,000 pounds per square inch at 1-day, 5,000 pounds per square inch at 3 days, and 9,000 pounds per square inch at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturer and Product:
   a. Master Builders Solutions, Shakopee, MN; MasterFlow 885.
   b. Euclid Chemical Co, Cleveland, OH; Hi-Flow Metallic Grout.

2.03 EPOXY GROUT

A. High-strength, nonshrink, high-temperature epoxy grouting material developed for the support of heavy equipment with vibratory loads.

B. Three-component mixture of a two-component epoxy resin system (100 percent solids) with a graded, precision aggregate blend.

C. Premeasured, prepackaged system.

D. Flowable.

E. Minimum compressive strength in accordance with ASTM C579 Method B, 9,500 pounds per square inch at 75 degrees F at 7 days, 11,000 pounds per square inch at post cure.

F. Maximum creep resistance in accordance with ASTM C1181 at 600 pounds per square inch, 140 degrees F; 6.0 by 10^{-3} in/in.

G. Minimum bond strength in accordance with ASTM C882, 2,000 pounds per square inch.

H. Minimum tensile strength in accordance with ASTM C307, 2,000 pounds per square inch.

I. Maximum coefficient of thermal expansion in accordance with ASTM C531 at 73 degrees F to 210 degrees F, 23.0 by 10^{-6} in/in/degrees F.

J. Working Time: Minimum 2 hours at 50 degrees F; 1-1/2 hours at 70 degrees F; 50 minutes at 90 degrees F.

K. Good chemical resistance.

L. Good effective bearing area.

M. Noncorrosive.

N. Moisture insensitive.

O. Modify resin and aggregate content where recommended by epoxy grout manufacturer to provide desired epoxy grout flow properties.

P. Manufacturer and Product:

1. Master Builders Solutions, Shakopee MN; MasterFlow 648.
2. Euclid Chemical Co., Cleveland, OH; E^3-Series.
3. Dayton Superior Corp., Miamisburg, OH; Pro-Poxy 2000 Normal Set.
4. Five Star Products Inc., Fairfield, CT; DP Epoxy Grout.

PART 3 EXECUTION

3.01 GENERAL

A. Unless otherwise specified, prepare and condition concrete substrate in accordance with grout manufacturer’s training instructions.

B. Mix, place, and cure grout in accordance with grout manufacturer’s representative’s training instructions.

C. Epoxy Grout: Concrete slab shall be fully cured for 28 days to ensure excess water has evaporated. Test concrete surface for moisture in accordance with ASTM D4263 before epoxy grout is placed.

D. Form Tie-Through Bolt Holes: Provide nonshrink grout, Category II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes; coordinate dry pack dense grout application with vinyl plug in Section 03100, Concrete Forming and Accessories, and bonding agent in Section 03300, Cast-in-Place Concrete.

E. Form Snap-Tie Hole: Fill tie hole in accordance with requirements of Section 03300, Cast-in-Place Concrete.

3.02 GROUTING MACHINERY FOUNDATIONS

A. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material. Surface roughness in accordance with manufacturer’s written instructions.

B. Clean metal surfaces of all paint, oil, grease, loose rust, and other foreign material that will be in contact with grout.

C. Sandblast to bright metal all metal surfaces in contact with epoxy grout in accordance with manufacturer’s written instructions.

D. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts. Remove wedges after grout is set and pack void with grout.

E. Form with watertight forms at least 2 inches higher than bottom of plate.

F. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's representative's training instructions.

G. If grout cannot be placed from one edge and flowed to the opposite edge, air vents shall be provided through the plate to prevent air entrapment.

H. Radius corners of grout pad.

I. Install expansion joints for epoxy grout placement in accordance with manufacturer's written instructions.

3.03 FIELD QUALITY CONTROL

A. General:

1. Performed by Project representative's inspection staff.
2. Perform the following quality control inspections. Grout manufacturer's representative shall accompany the Project representative's inspection staff on the first installation of each size and type of equipment.

B. Evaluation and Acceptance of Nonshrink Grout:

1. Inspect surface preparation of concrete substrates onto which nonshrink grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
2. Inspect preparation and application of nonshrink grout form work for conformance to the manufacturer's recommendations.
3. Conduct a final review of completed nonshrink grout installation for conformance to these Specifications.
4. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
5. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/C1107M.
6. For large grout applications, make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.

7. Consistency: As specified in Article Nonshrink Grout. Flow cone test in accordance with ASTM C939. Grout with consistencies outside range requirements shall be rejected.
8. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
9. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.
10. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
11. Perform bleeding test in accordance with ASTM C940 to demonstrate grout will not bleed.
12. Store cubes at 70 degrees F.
13. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.
14. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

C. Evaluation and Acceptance of Epoxy Grout:

1. Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer’s requirements.
2. Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
3. Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.
4. Inspect the epoxy-primed metallic substrate for coverage and adhesion.
5. Inspect preparation and application of epoxy grout form work for conformance to the manufacturer’s recommendation.
6. Verify consistency obtained is sufficient for the proper field placement at the installed temperatures.
7. Inspect and record that the “pot life” of epoxy grout materials is not exceeded during the installation.
8. Inspect epoxy grout for cure.
9. Inspect and record that localized repairs made to grout voids are in conformance with the specification requirements.
10. Conduct a final review of completed epoxy grout installation for conformance to these Specifications.

11. Compression tests and fabrication of specimens for epoxy grout shall be made in accordance to ASTM C579, Method B, at intervals during construction as selected by the Project representative. Set of three specimens shall be made for testing at 7 days, and each earlier time period as appropriate.
12. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C579.
13. Grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

3.04 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

SUPPLEMENT 1

_____

(Test Lab Name)

_____

(Address)

_____

(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain three bags of each type of grout.

1. From intended grout supplier for Project.
2. Three bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A.	Product data and warranty information contained in company literature and data?	Yes_____ No_____
B.	Literature and bag information meet specified requirements?	Yes_____ No_____
C.	Manufacturer guarantees grout?	Yes_____ No_____
D.	Guarantee extends beyond grout replacement value and allows participation with Contractor in replacing and repairing defective areas?	Yes_____ No_____
E.	Water demands and limits printed on bag?	Yes_____ No_____
F.	Mixing information printed on the bag?	Yes_____ No_____
G.	Temperature restrictions printed on bag?	Yes_____ No_____

*Rejection of a grout will occur if one or more answers are noted NO.

GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____
2. List expiration date. _____
3. Weigh bags and record weight. _____

Owner's Representative will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of three bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10-gallon pail.
2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).
3. Use maximum water allowed per water requirements listed in bag instructions.
4. Mix grout to maximum time listed on bag instructions.
5. In accordance with ASTM C939 (flow cone) determine time of mixed grout through the flow cone. _____ seconds.
6. Add water to attain 20-second to 30-second flow in accordance with ASTM C939.
7. Record time of grout through cone at new water demand. _____ seconds
8. Record total water needed to attain 20- to 30-second flow. _____ pounds
9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, ASTM C1107/C1107M will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.
2. Place one can of grout in tub of ice water and leave one can at ambient temperature.
3. Cover top of both cans with glass or plastic plate preventing evaporation.
4. Maintain 38 degrees F to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1-hour.
5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and Category III):

1. Divide the remaining grout into two 3-gallon cans. Place the cans into the 40-degree F and 90-degree F containers and leave for 20 minutes, 40 minutes, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4-inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take an ASTM C939 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 degrees F and 90 degrees F.

   a. 20 min _____, sec. @ 40 degrees F.

   b. 40 min _____, sec. @ 40 degrees F.

   c. 60 min _____, sec. @ 40 degrees F.

   d. 20 min _____, sec. @ 90 degrees F.

   e. 40 min _____, sec. @ 90 degrees F.

   f. 60 min _____, sec. @ 90 degrees F.

All Category II and Category III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

_____ _____

Qualified Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with ASTM C1107/C1107M for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are less than 2,500 pounds per square inch for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____ _____

Signature of Independent Testing Laboratory Date Test Conducted

SECTION 03720
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03300, Cast-in-Place Concrete.

C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.

E. New Concrete: As defined in Section 03300, Cast-in-Place Concrete.

1.02 SUBMITTALS

A. Action Submittals: Product data sheets for each material supplied.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer’s preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Statements of Qualification: Repair mortar system applicator.
4. Repair mortar system manufacturer’s proposed modified test procedures for ASTM C109/C109M, ASTM C882/C882M, and ASTM C157/C157M test methods.
5. Field and laboratory test reports.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR

A. One-component or two-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 pounds per square inch minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,100 pounds per square inch minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 pounds per square inch minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 pounds per square inch minimum.
5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
7. System shall not produce a vapor barrier.
8. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
9. Free of chlorides and other chemicals causing corrosion.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 488CI.
2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.
3. Euclid Chemical Co., Cleveland, OH; Tamms Structural Mortar.

2.02 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR

A. Polymer-modified, one-component or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 pounds per square inch minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 pounds per square inch minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 pounds per square inch minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 pounds per square inch minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1-square foot in area or less.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and belowgrade repairs.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco N 300CI.
2. Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.
3. Euclid Chemical Co., Cleveland, OH; DuralTop Gel.

2.03 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03300, Cast-in-Place Concrete.

2.04 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03210, Steel Reinforcement.

B. Tie Wire: 16-gauge, galvanized.

2.05 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Mixed Bonding Agent Properties:
   a. Pot Life: 75 minutes to 105 minutes.
   b. Contact Time: 24 hours.
2. Cured Cementitious Adhesive Properties:
   a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 pounds per square inch minimum.
   b. Flexural Strength, ASTM C348: 1,000 pounds per square inch minimum.
   c. Slant Shear Bond Strength, ASTM C882/C882M at 14 Days:
      1) 2-Hour Open Time: 2,500 pounds per square inch minimum.
      2) 24-Hour Open Time: 2,000 pounds per square inch minimum.
3. Bonding agent shall not produce a vapor barrier.
4. Compatible with and from same manufacturer as the repair system used.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH: Dural Prep AC.

2.06 EVAPORATION RETARDANT

A. As specified in Section 03370, Concrete Curing.

2.07 CURING COMPOUND

A. As specified in Section 03370, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03300, Cast-in-Place Concrete.

3.02 APPLICATION

A. General:

1. Repair System B: Medium to large areas and number of repair areas.
2. Repair System C: Small and limited areas and number of repair areas.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.

B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.

1. Use 8,000 pounds per square inch minimum high-pressure water blasting machine as required for Site conditions.
2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16-inch measured between high and low points with a 3-foot long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer’s printed instructions.

K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used.

3.05 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Bonding Agent:

1. Use bonding agent when manufacture required for hand applied areas, in accordance with repair mortar manufacturer's instructions.
2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.

D. Work mortar firmly and quickly into repair area.

E. Finish repair mortar to match adjacent concrete surface.

F. Cure as specified in Article Curing.

3.06 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

D. Finish repair mortar to match adjacent concrete surface.

E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.07 CURING

A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.

B. Cure in accordance with repair mortar manufacturer's printed instructions.

C. Where permitted by repair mortar manufacturer's printed instructions, commence water curing after repair mortar system application and when curing will not cause erosion of mortar.

D. Continuously water cure repair mortar system for a period of 7 days.

E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.

F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03370, Concrete Curing.

3.08 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days.
3. Provide a minimum of three samples for each 1,000 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Testing laboratory retained by Contractor will provide the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 1,000 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.

D. Retest mortar repairs that do not meet test requirements.

3.09 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.10 CLEANING

A. Remove overshot repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

SECTION 03722
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03300, Cast-in-Place Concrete.

C. High-Pressure Water Blasting (sometimes referred to as hydro-demolition): Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. New Concrete: As defined in Section 03300, Cast-in-Place Concrete.

1.02 SUBMITTALS

A. Action Submittals: Product data sheets for each material supplied.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer’s preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Statements of Qualification: Repair mortar system applicator.
4. Field and laboratory test results.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR MORTAR SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

A. One-component or two-component cement-based, flowable, shrinkage compensated repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1-Day: 2,500 pounds per square inch minimum.
2. 7 Days: 6,000 pounds per square inch minimum.
3. 28 Days: 8,000 pounds per square inch minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 770 pounds per square inch minimum.

D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10^6 pounds per square inch minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M Modified:

1. 7 Days: 2,150 pounds per square inch minimum.
2. 28 Days: 3, 000 pounds per square inch minimum.

F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97.0 percent RDM.

G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.

H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.

I. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 466 CI.
2. Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.

2.02 REPAIR MORTAR SYSTEM NO. 5—POLYMER MODIFIED REPAIR MORTAR

A. One-component or two-component, fast-setting, polymer modified cementitious based repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1-Day: 2,500 pounds per square inch minimum.
2. 7 Days: 5,000 pounds per square inch minimum.
3. 28 Days: 7,000 pounds per square inch minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 1,500 pounds per square inch minimum.

D. Slant Shear Bond Strength, ASTM C882/C882M Modified at 28 Days: 2,000 pounds per square inch minimum.

E. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 pounds per square inch minimum.

F. Abrasion Resistance Depth of Wear, ASTM C779/C779M, Procedure A, at 60 Minutes: 0.033-inch maximum.

G. Drying Shrinkage, ASTM C157/C157M Modified, at 28 Days: 0.09 percent maximum.

H. Rapid Chloride Ion Permeability Based on Charge Passed, ASTM C1202:

1. 28 Days: Under 850 coulombs maximum.

I. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco T 310 CI.
2. Euclid Chemical Co., Cleveland, OH; Duraltop Flowable Mortar.

2.03 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03300, Cast-in-Place Concrete.

2.04 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03210, Steel Reinforcement.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer's recommendations.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

1. Manufacturers and Products:
   a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
   b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

2.05 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Mixed Bonding Agent Properties:
   a. Pot Life: 75 minutes to 105 minutes.
   b. Contact Time: 24 hours.
   c. Concrete gray.
2. Cured Cementitious Adhesive Properties:
   a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 pounds per square inch minimum.
   b. Flexural Strength, ASTM C348: 1,000 pounds per square inch minimum.
   c. Slant Shear Bond Strength, ASTM C882/C882M:
      1) 2-Hour Open Time: 2,500 pounds per square inch minimum.
      2) 24-Hour Open Time: 2,000 pounds per square inch minimum.

3. Bonding agent shall not produce a vapor barrier.
4. Compatible with, and from same manufacturer as the repair mortar system used.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH; Dural Prep AC.

2.06 EPOXY BONDING AGENT

A. Two-component, moisture insensitive, 100 percent solids epoxy resin.

B. Tensile Strength, ASTM D638, at 14 Days: 4,400 pounds per square inch minimum.

C. Elongation at Break, ASTM D638: 1.49 percent minimum.

D. Compressive Strength, ASTM D695, at 28 Days for Application Temperature of 73 Degrees F to 77 Degrees F: 8,000 pounds per square inch minimum.

E. Bond Strength, ASTM C882/C882M, at 14 Days: 1,800 pounds per square inch minimum.

F. Pot Life, at 73 Degrees F to 77 Degrees F: 75 minutes minimum.

G. Manufacturer and Product: BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco ADH 326 when ambient temperature is 73 degrees F or higher.

2.07 EVAPORATION RETARDANT

A. As specified in Section 03370, Concrete Curing.

2.08 CURING COMPOUND

A. As specified in Section 03370, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system.

3.02 APPLICATION

A. General:

1. Repair Mortar System No. 3: Patches, joints, or overlays 1-inch thick or greater. Return to service in 7 days or more.
2. Repair Mortar System No. 5:
   a. Patches and Overlays: 1/4-inch to 3 inches thick.
   b. Return to service for foot traffic in 4 hours; wheel traffic in 7 days.
   c. Working Time: 30 minutes at 70 degrees F.
   d. Application Temperature Range: 45 degrees F to 90 degrees F.

3.03 PREPARATION FOR REPAIR

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer. Review proposed extent of repair with Engineer.

B. Remove unsound, deteriorated, or otherwise defective areas of concrete from Work areas.

1. Use 7,000 pounds per square inch minimum high-pressure water blasting machine, as appropriate to suit Site conditions.
2. Remove concrete to abrade substrate concrete surface to a minimum amplitude roughness of 3/16-inch measured between high and low points with a 3-foot long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface, remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, scabblers, or scarifiers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to entire circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System No. 3 and No. 5: Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer’s printed instructions.

K. Spalled Joints:

1. Saw cut edge 1-inch deep and 6 inches back from old joint.
2. Remove unsound concrete and concrete between saw cut and joint.
3. Place wood or fiber spacer to thickness of joint at joint line.

L. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

A. Coat exposed new and existing steel reinforcement with cementitious reinforcement coating at the same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

3.05 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

3.06 PLACEMENT

A. Repair Mortar System No. 3 and No. 5:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.
7. Repair Mortar System No. 5 screed or use self-leveling mixture to obtain a uniform and plane surface.

3.07 CURING

A. Repair Mortar System No. 3 or No. 5: Apply curing compound in accordance with Section 03370, Concrete Curing.

3.08 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Chain drag or light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed materials from mixer during construction for compliance with these Specifications.
3. Provide minimum of three samples for each 1,000 square feet of mortar repair, and a minimum of three samples in total, whichever is greater for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Testing laboratory retained by Contractor will provide the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 1,000 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.

D. Retest mortar repairs that do not meet test requirements.

3.09 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge, remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.10 CLEANING

A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

END OF SECTION

SECTION 03740
EPOXY RESIN INJECTION GROUTING

PART 1 GENERAL

1.01 DEFINITIONS

A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

B. Defective Area: As defined in Section 03300, Cast-in-Place Concrete.

C. Hydraulic Structure: Liquid containment structure and/or structure designed to mitigate liquid infiltration.

D. Injection: Method of bonding together, addressing or eliminating leakage through cracks or joints by installing resin under pressure to fill the void in crack or joint.

E. Joint: A planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements and may contain embedded waterstops.

F. Leak or Leakage: Crack or joint exhibiting presence of moisture, sign of efflorescence, intermittently wet to touch, or continuous flow of liquid.

G. Narrow Cracks: Width equal to or less than 0.015-inch.

H. Wide Cracks: Wider than 0.015-inch.

1.02 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for epoxy resin.
2. Technical data for metering, mixing, and injection equipment.
3. Depth of penetration, length, material used, and procedures where epoxy is approved for use.
4. Marked up drawings of proposed epoxy injection repair crack locations, widths, and lengths and direction on structure.
5. Sample bottle.
6. Pot Life Test.
7. Slant Shear Test (Bond Strength).

B. Informational Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy resins.
2. Statements of Qualification for Epoxy Resin:
   a. Manufacturer's Site representative.
   b. Injection applicator.
   c. Injection pump operating technician.
3. Epoxy resin two component ratio and injection pressure test records for concrete crack repair work.

1.03 QUALITY ASSURANCE

A. Qualifications for Injection Staffs:

1. Injection Crew and Job Foreman:
   a. Provide written and verifiable evidence showing compliance with the following requirements:
      1) Licensed or certified by epoxy resin material manufacturer.
      2) Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection, including 2,000 linear feet of wet crack injection to stop water leakage.

B. Injected Epoxy Resin: Fill cracks with minimum resin depth penetration no less than 90 percent of full thickness of concrete section for cracks or joints.

C. Injected cracks which leak shall be considered deficient work irrespective of depth of penetration. Reinjection of deficient work or, with approval of Engineer, provide other repairs to eliminate leakage.

D. Bond Strength Test for Epoxy Resin:

1. Concrete failure before resin failure.
2. 1,500 pounds per square inch minimum bond strength per ASTM C882 test requirements with no failure of either concrete or epoxy resin.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package resin material in new sealed containers and label with following information:
   a. Manufacturer's name.
   b. Product name and lot number.

B. Storage and Protection: Store epoxy resin material containers in accordance with manufacturer's printed instructions and at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and accessories specified in this section shall be products of:

1. BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; SCB Concresive Series products that meet properties indicated in sub-section 2.2.B.
2. Sika Corp., Lyndhurst, NJ; Sikadur Series products that meet properties below.
3. Euclid Chemical Co., Cleveland, OH; Euco Series (No. 452) products that meet properties below.

2.02 EPOXY INJECTION RESIN

A. Two-component A and B structural epoxy resin for injection into cracks in concrete structures for bonding or grouting.

B. Uncured Resin Properties:

1. When mixed in ratio specified on resin container label:

	Test Method	**Wide Cracks or Joints**	**Narrow Cracks or Joints**
Pot Life (60-gram mass) at 77, plus or minus 4 degrees F	As specified in Article Source Quality Control	13 to 25 minutes	15 to 30 minutes
Pot Life (60-gram mass) at 100, plus or minus 4 degrees F	As specified in Article Source Quality Control	3 to 10 minutes	10 to 20 minutes
Viscosity at 40, plus or minus 3 degrees F	Brookfield RVT Spindle No. 4 at 20 rpm	4,400 cps	600 cps
Viscosity at 75 to 77 degrees F	Brookfield RVT Spindle No. 2 at 20 rpm	375 to 350 cps	175 to 140 cps

C. Epoxy Resin Properties: When cured for 7 days at 77 degree F, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Ultimate Tensile Strength, psi	ASTM D368	8,000 min.	5,000 min.
Tensile Elongation at Break, percent	ASTM D638	4.2 max.	3.0 max.
Flexural Strength, psi	ASTM D790	10,000 min.	10,000 min.
Flexural Modulus, psi	ASTM D790	5.5×10^5 min.	4.5×10^5 min.
Compressive Yield Strength, psi	ASTM D695*	15,000 min.	12,000 min.
Compressive Modulus, psi	ASTM D695*	4.0×10^5 min.	4.0×10^5 min.
Heat Deflection Temperature	ASTM D648*	130 degrees F min.	140 degrees F min.
Cured 3 days at 40 degrees F – Wet Concrete		3,500 psi min.	3,500 psi min.
Cured 1-day at 77 degrees F – Dry Concrete		5,000 psi min.	5,000 psi min.
Cured 3 days at 77 degrees F plus or minus 3 degrees F		5,000 psi min.	5,000 psi min.

*Cure test specimens so that peak exothermic temperature of resin does not exceed 100 degrees F.

Note: See referenced specifications for preparation method of test specimens.

2.03 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in place and to resist pressures preventing leakage during injection.

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.05 SAMPLE BOTTLE

A. Five-inch natural wide mouth HDPE bottle or 4-ounce clear PVC cylinder bottle; supplied with caps.

2.06 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of epoxy resin.

B. Pot Life Test:

1. Condition Component A and Component B to required temperature.
2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
3. Mix components for 60 seconds using non-metallic stirring instrument. Scrape sides and bottom of cup periodically.
4. Probe mixture once with non-metallic stirring instrument every 30 seconds, starting 2 minutes prior to minimum specified pot life.
5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.

C. Slant Shear Test: Prepare specimens and perform tests in accordance with ASTM C882.

PART 3 EXECUTION

3.01 GENERAL

A. Unless permitted otherwise, structurally repair cracks listed below:

1. Cracks considered to be defective as defined in Section 03300, Cast-in-Place Concrete.

B. Do not proceed with injection work until submittals have been reviewed and approved by Engineer.

C. Perform cracks injection work after removing defective surface materials and after performing surface preparation, but prior to applying surface repair material unless otherwise noted. See Section 03720, Repair of Vertical and Overhead Concrete Surfaces, Section 03722, Repair of Horizontal Concrete Surfaces, for concrete surface repair system.

D. Width of cracks may vary along length and through thickness of concrete section.

E. Remove all excess, unused epoxy resin materials on concrete surfaces exposed to view prior to end of Work.

3.02 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two epoxy resin components and inject mixture into cracks or joints.

B. Pumps:

1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
3. Capable of immediate compensation for changes in resins.
4. Do not use batch mix pumps.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed epoxy resin at pressures in accordance with epoxy resin manufacturer's printed instruction and able to maintain pressure.

D. Automatic Shutoff Control: Provide sensors on both Component A and Component B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: Maintain epoxy resin manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 pounds per square inch.

F. Ratio/Pressure Check Device:

1. Two independent valve nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.03 PREPARATION

A. Free cracks from loose matter, dirt, laitance, oil, grease, efflorescence, salt, and other contaminants.

B. Clean cracks in accordance with epoxy resin manufacturer's instructions.

C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instruction.

D. Do not use acids and corrosives for cleaning, other than those specified herein unless neutralized prior to injecting epoxy resin.

E. During installation and curing of materials, if ambient temperature is expected to drop below manufacturer's recommended minimum temperature, provide enclosures and heat as required.

F. Provide work platforms as required.

G. Dry out cracks or joints if required by manufacturer's instructions.

3.04 APPLICATION

A. All liquid is to be removed from hydraulic structure prior to commencing with epoxy injection, unless approved otherwise.

B. Entry Ports:

1. Establish openings for epoxy resin entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow epoxy resin to penetrate to the full thickness of the member.
3. Drill injection holes at an angle between 45 degrees and 60 degrees from surface of concrete and perpendicular to alignment of cracks, to intersect crack at midpoint of concrete section, and intersect joints at midpoint between waterstop and concrete surface, except as noted otherwise.
4. Locate drill holes on alternate sides of crack where possible, unless orientation of crack is known or has been verified by non-destructive testing techniques or core drilling.
5. Drill Hole Spacing: Do not to exceed concrete thicknesses or 12 inches maximum, except as noted otherwise.
6. Adjust location and angle of drill holes to suit orientation of crack and at commencement of drilling holes for injection.
7. Take measures to prevent drilling holes for injection too shallow or too deep, or damaging existing waterstop in joints.
8. Remove dust and debris in drill holes and on surface of structure resulting from drilling operation, by flushing with water prior to installing the injection packers or ports.
9. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
    a. Cracks or joints extend entirely through concrete element.
    b. Backfill of walls on one side.
    c. Slab-on-grade.
    d. Difficult to excavate behind wall to seal both surfaces of crack.

10. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks.

C. Application of Surface Seal along Cracks:

1. Apply surface seal in accordance with manufacturer's instructions to designated cracks face prior to injection. Seal surface of cracks to contain and prevent escape of injection epoxy.
2. Cure surface seal in accordance with manufacturer's printed instructions before commencing inject work.

D. Epoxy Injection:

1. Ensure zerk coupling is not installed in ports or packers next to the one being injected.
2. Start injection into each crack at lowest elevation entry port or packer along vertical or diagonal crack, and at one end of horizontal crack.
3. Where injection entry ports or packers are used, continue injection at first port or packer until resin begins to flow out of port or packer at next highest elevation. Plug first port or packer and start injection at second port or packer until resin flows from next port or packer.
4. Inject entire crack with same sequence.
5. At no time inject more than 6 feet length of first vertical crack before verifying resin in sample bottle has start to set and cure.
6. Prior to commencing injection work along a horizontal crack in structure when processed using ports or packers with zerk couplings are used, remove zerk couplings from injection ports or packers except for two ports or packers located where injection work will commence. Commence injection work in first two ports or packers. Once clean resin is vented from third injection port or packer, cease injection at first port or packer, and install zerk coupling and commence injection at third port or packer. Repeat process for fourth and subsequent ports or packers until full length of crack has been injected.

E. Finishing:

1. Allow epoxy resin to cure in accordance with manufacturer's instruction after cracks have been completely injected to allow surface seal removal without draining or runback of uncured epoxy resin material from cracks.
2. Remove surface seal and injection packers from cured injection resin along crack.
3. Finish crack faces flush with adjacent concrete.

4. Indentations or protrusions caused by placement of entry ports, packers, drill holes, or damage from removal of surface seal is not acceptable.
5. Grind off protrusions and patch indentations and holes from injection packers and entry ports with a suitable patch material to satisfaction of Engineer.
6. Remove surplus surface seal material splatters and injection resin material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Epoxy Resin Two Component Ratio Tests:

1. Disconnect mixing head and pump two resin components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 pounds per square inch for both resin components.
3. Simultaneously discharge both resin components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 pounds per square inch discharge pressure and repeat procedure for 0-pound per square inch discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1-hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two resin component delivery lines to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 pounds per square inch.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 pounds per square inch within 3 minutes.
5. Run pressure test for each injection equipment unit:
   a. Beginning and end of each injection work day.
   b. When injection work stop for more than 45 minutes.

6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Bottled Sample Tests:

1. During injection operation, provide at least one sample of mixed epoxy resin for each injection pump per shift per injection work day in a sample bottle.
2. Provide sufficient sample to demonstrate sample material epoxy resin will set and cure correctly.
3. Label each bottled sample with Contractor's name, date, and time sample was taken, and location in structure where sample was taken. Record details of bottle sample tests.
4. Place filled sample bottle upright in a container and allow sample to cure.
5. After sample has been allowed to cure, cut bottled sample open and visually inspect contents to verify that epoxy resin material has completely reacted and cured.
6. Evaluation and Assessment of Test:
   a. Should bottled sample(s) indicate a problem; such as epoxy resin not cured or foreign liquid in sample bottle, take verifying core sample immediately from cracks, where material was used.
   b. Should above-referenced bottle sample(s) and core sample(s) indicate a problem with epoxy resin, arrange to have a Technical Representative of the epoxy resin manufacturer come to Site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
   c. Carry out further investigation work or corrective measures recommended by Technical Representative of epoxy resin manufacturer.

END OF SECTION

SECTION 03744
POLYURETHANE INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. D638, Standard Test Method for Tensile Properties of Plastics.
   b. D1622, Standard Test Method for Apparent Density of Rigid Cellular Plastics.
   c. D1623, Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics.
   d. D3574, Standard Test Method for Flexible Cellular Material Slab, Bonded, and Molded Urethane Foams.
2. National Sanitation Foundation (NSF):
   a. Standard 60, Standard for Drinking Water Treatment and Chemicals—Health Effects.
   b. Standard 61, Standard for Drinking Water System Components—Health Effects.

1.02 DEFINITIONS

A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

B. Injection: Method of bonding together; method of addressing or eliminating leakage through cracks or joints by installing polymer under pressure to fill the void in crack or joint.

C. Joint: Planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements, and may contain embedded waterstops.

D. Leak or Leakage: Crack or joint exhibiting moisture, sign of efflorescence, intermittent wet to touch, or continuous flow of liquid.

E. Narrow Cracks: Width equal to or less than 0.015-inch.

F. Wide Crack: Wider than 0.015-inch.

1.03 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for polyurethane injection resin.
2. Technical data for metering, mixing, and injection equipment.
3. Submit:
   a. Marked up drawings showing locations of proposed polyurethane injection work, including the following:
      1) Exact locations for injection.
      2) Depth of penetration or crack.
      3) Width of crack measured every 4 feet minimum.
      4) Length of penetration or crack.
   b. Proposed materials.
   c. Injection procedure, including the following:
      1) Preparation of penetration for polyurethane.
      2) Fittings for installation for injection.
      3) Temperature of installation.
      4) Measurement and monitoring of injection pressure.
      5) Surface cleaning and repair.
4. Sample bottle.

B. Informational Submittals:

1. Manufacturer’s recommended surface preparation procedures and application instructions for polyurethane resin injection.
2. Manufacturer’s Certificate of Compliance in accordance with Section 01600, Common Product Requirements. Certified test results for each batch of polyurethane.
3. Statements of Qualification for Polyurethane Resin Injection:
   a. Manufacturer’s Site representative.
   b. Injection applicator.
   c. Injection pump operating technician.
4. Health and Safety Plans for confine space entry.
5. Sample of polyurethane resin mix ratio and injection pressure test records for concrete crack and joint injection work.
6. Installation instructions for repairing core holes with repair mortar.
7. Polyurethane resins injection pressure test records for concrete crack and joint injection work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staff:

1. Manufacturer's Site Representative:
   a. Capable of instructing successful methods of polyurethane injection process for concrete structures.
   b. Understands and is capable of explaining technical aspects of correct material selection and use.
   c. Experienced in the operation, maintenance, and troubleshooting of application equipment.
2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
   a. Licensed or certified by polyurethane resin manufacturer.
   b. Minimum 3 years' experience in successful polyurethane injection.

1.05 PERFORMANCE REQUIREMENTS

A. Injected polyurethane resin shall fill cracks and joints, and in no case shall depth of penetration of injection material be less than 90 percent of:

1. Full thickness of the concrete section for cracks.
2. Depth between the waterstop and the inside face of the structure for joints.

B. In cured state, injected polyurethane resin forms a dense rubber-like closed cell flexible foam compression gasket-type seal material.

C. Notwithstanding the foregoing, injected cracks or joints which exhibit leakage are considered deficient work irrespective of the depth of penetration observed in quality control core drilled samples. Reinject deficient work as required to meet the performance requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package adhesive material in new sealed containers and label with following information:
   a. Manufacturer's name.
   b. Product name and lot number.

B. Storage and Protection: Store polyurethane resin material containers in accordance with manufacturer's printed instructions or in the absence of such information at ambient temperatures below 110 degrees F and above 68 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corp., Lyndhurst, NJ; SikaFix HH Hydrophilic.

B. Euclid Chemical Co., Cleveland, OH; DURAL Aqua-Fil.

C. Prime Resins, Inc., Conyers, GA; Prime Flex 900 XLV.

2.02 POLYURETHANE RESIN

A. Single-component, water-activated, hydrophilic polyurethane injection resin.

B. Accelerator: Compatible with polyurethane resin from same manufacturer.

C. Elongation: Minimum 350 percent, in accordance with ASTM D3574 or ASTM D638 test method.

D. Tensile Strength: Minimum 150 pounds per square inch, in accordance with ASTM D3574 or ASTM D638 test method.

E. Shrinkage: Less than 2 percent.

2.03 SURFACE SEAL

A. Provide seal with sufficient strength and adhesion for holding injection fittings firmly in place, and to resist pressures preventing leakage during injection.

B. Capable of removal after injection resin has cured.

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.05 SAMPLE BOTTLE

A. 5 inches natural wide mouth HDPE bottle or 4 ounces clear PVC cylinder bottle, supplied with caps.

2.06 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of polyurethane resins.

PART 3 EXECUTION

3.01 GENERAL

A. Use of polyurethane injection shall be limited to locations as determined by Structural Engineer.

B. Do not proceed with injection work until action submittals have been reviewed and approved by the Structural Engineer of Record.

C. Perform injection work after performing surface preparation.

D. Width of the cracks shown may vary along the length and through the thickness of the concrete section.

E. Remove all excess unused polyurethane resins materials inside the structure prior to the end of the work.

3.02 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter mixed components, and inject mixture into crack or joint.

B. Pumps:

1. Positive displacement type pump.
2. Equip the polyurethane injection equipment with pail heater(s) suitable for plastic pails capable of maintaining the polyurethane resin and accelerator mixture between 50 degrees F and 160 degrees F.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed polyurethane resin at pressures in accordance with polyurethane resin manufacturer’s printed instructions, and able to maintain such pressure.

D. Proportioning Ratio Tolerance: Maintain polyurethane manufacturer’s prescribed mix ratio within a tolerance in accordance with polyurethane resin manufacturer’s printed instructions.

E. Pressure gauge capable of sensing pressure behind valve.

3.03 PREPARATION

A. Free cracks and joints from loose matter, dirt, laitance, oil, grease, salt, and other contaminants.

B. Clean cracks and joints in accordance with polyurethane resins manufacturer's printed instructions.

C. Clean surfaces adjacent to cracks and joints from dirt, dust, grease, oil, efflorescence, encrustation, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instructions.

D. Do not use acids and corrosives for cleaning, other than those specified herein, unless neutralized prior to injecting polyurethane resin.

E. During installation and curing of materials, if the ambient temperature is expected to drop below the manufacturer's recommended minimum temperature, provide enclosures and heat as required.

F. Provide work platforms as required.

3.04 APPLICATION

A. Injection Ports:

1. Drill holes shall be installed along cracks and joints designated for injection as required to meet the performance requirements for injection.
2. The requirements for installing drill holes for injection provided below represent acceptable minimum standards of practice.
3. Drill holes for injection at an angle between 45 degrees and 60 degrees from the surface of the concrete and perpendicular to the cracks or joints alignment, to intersect the cracks at the midpoint of the concrete section, and intersect the joints at the midpoint between the waterstop and interior concrete surface, except as noted otherwise.
4. Locate drill holes on alternate sides of the crack or joint where possible, unless orientation of the crack or joint is known or has been verified by nondestructive testing techniques or core drilling.
5. The spacing of drill holes not to exceed the concrete thickness or 12 inches (maximum), except as noted otherwise.
6. Adjust location and angle of drill holes to suit orientation of crack or joint and at required angle, such as using a template, during the Work especially at the commencement of drilling holes for injection and at the beginning of each subsequent shift.

7. Take measures to prevent drilling holes for injection too shallow, or too deep, and/or damaging the existing waterstop in the joints. Shallow hole injections lead to concrete spalls. Repair spalls at Contractor's expense.
8. Remove dust and debris in drill holes and on interior surface of the structure resulting from drilling operation, by flushing with water prior to installing injection packers or ports.
9. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling, or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks and joints.

B. Application of Surface Seal Along Cracks and Joints:

1. Apply surface seal along the length of the cracks and joints designated for injection on the top side and underside of slabs, or both sides of walls, where possible in order to contain, confine, and prevent escape of the injected polyurethane resin, in accordance with manufacturer's printed instructions.
2. Cure the surface seal in accordance with the material's manufacturer's printed instructions.

C. Mixing Polyurethane Injection Resin: Add accelerator to polyurethane injection resin at the required dosage to produce cured polyurethane material meeting performance requirements, and mix thoroughly in accordance with manufacturer's printed instructions until a homogeneous mixture is obtained outside of the structure.

D. Polyurethane Injection of Cracks and Joints:

1. Inject polyurethane resins, mixed with accelerator or in a neat form, into cracks and joints in a sequential manner, and reinjection as required, to meet the performance requirements.
2. Start injection into each crack or joint at lowest elevation entry port for vertical or diagonal cracks and joints and at one end for horizontal cracks and joints in vertical structure. Continue injection at first port until pure uncontaminated resin begins to flow out of next port. Plug first port and start injection at second port until polyurethane resin flows from next port. Inject crack or joint in a sequential manner until the full length of the crack or joint has been injected. At no time inject more than 6 feet length of vertical crack or joint before verifying that the first 12 inches of injected crack or joint is set and cured.

3. Prior to commencing the injection work along a crack or joint in horizontal structure when packers with zerk couplings are used, remove the zerk couplings from the injection packers or ports except for the two packers located where the injection work will commence. Commence injection work in the first two packers. Once clean resin is vented from the third injection packer, cease injection at the first packer, and install the zerk coupling and commence injection at the third packer. Repeat the process for the fourth and subsequent packers until the full length of the crack or joint has been injected.

E. Finishing:

1. Cure polyurethane resins after crack or joints has been completely filled without draining or runback of polyurethane resin material from crack or joints.
2. Remove surface seal and injection packers or ports from along the crack or joints.
3. Finish surface flush and to match surrounding concrete.
4. Indentations or protrusions caused by placement of entry ports drill holes, or damage from removal of surface seal, is not acceptable.
5. Grind off protrusions, and patch indentations and holes from packers and ports with a suitable patch material to the satisfaction of the Engineer.
6. Remove surplus surface seal material on splatters and injection material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect polyurethane component delivery line to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 pounds per square inch.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 pounds per square inch within 3 minutes.
5. Run pressure Test for Each Injection Equipment Unit:
   a. Beginning and end of each injection work day.
   b. When injection work has stopped for more than 45 minutes.

6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

B. Bottled Samples:

1. During the injection operation, provide at least one sample of the mixed polyurethane injection resins per shift per injection pump in a sample bottle.
2. Half fill each sample bottle, containing a small amount of water (5 percent by volume) with polyurethane injection resin material from the pump discharge hose. Swirl or lightly shake sample to thoroughly mix resin with the water. When foaming rises near the top of the bottle, install the cap to contain the expanding resin material.
3. Label each bottled sample with Contractor's name, date and time sample was taken, and location in structure where sample was taken. Maintain a log of bottle samples.
4. Place filled sample bottle upright in a box or pail and allow sample to cure.
5. After sample cured, cut bottled sample open and visually inspect contents to verify that polyurethane injection resins material has completely reacted and cured.
6. Evaluation and Assessment of Test:
    a. If a bottled sample(s) indicates a problem with the polyurethane injection resins, such as polyurethane resin not cured; take verifying core sample immediately from the cracks or joints, where the material was used.
    b. If the above-referenced bottle sample(s) and core sample(s) indicate a problem with the polyurethane injection resins, have a Technical Representative of the polyurethane injection resins manufacturer come to site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
    c. Carry out further investigation work or corrective measures recommended by the Technical Representative of the polyurethane injection resins manufacturer.

C. Visual Inspection:

1. Confirm injection of polyurethane has stopped the leaking material.
2. Confirm installation of material is in accordance with manufacturers' requirements.
3. Confirm installation of material is not damaging concrete.

END OF SECTION

SECTION 04230
CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. C33, Standard Specification for Concrete Aggregates.
   d. C90, Standard Specification for Loadbearing Concrete Masonry Units.
   e. C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   f. C144, Standard Specification for Aggregate for Masonry Mortar.
   g. C150, Standard Specification for Portland Cement.
   h. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   i. C270, Standard Specification for Mortar for Unit Masonry.
   j. C404, Standard Specification for Aggregates for Masonry Grout.
   k. C476, Standard Specification for Grout for Masonry.
   l. C618 12 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   m. C744, Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units.
   n. C979, Pigments for Integrally Colored Concrete.
   o. C989, Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
   p. C1314, Standard Test Method for Compressive Strength of Masonry Prisms.
   q. C1403, Standard Test Method for Rate of Water Absorption of Masonry Mortars.
   r. E514/E514M, Standard Test Method for Water Penetration and Leakage through Masonry.
2. International Code Council (ICC):
   a. International Building Code (IBC).
   b. ICC Evaluation Service (ICC-ES) Reports.

3. The Masonry Society (TMS):
    a. TMS 402; Building Code Requirements for Masonry Structures and Companion Commentaries.
    b. TMS 602; Specification for Masonry Structures.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings.
2. Data Sheets:
    a. Horizontal joint reinforcement.
    b. Preformed control joint materials.
    c. Water repellant masonry sealer.
    d. Grout mix design.
    e. Mortar mix design.
    f. Grout sand gradation in accordance with ASTM C404.
3. Samples:
    a. Sample:
        1) One of each type of masonry unit to be used on Project from the proposed manufacturer.
        2) One of each, textured, glazed, and sound absorbing units for selection of color and texture for each batch of manufacturer.
    b. Mortar colors for color selection.

B. Informational Submittals:

1. Method and Location of Placing Grout: High lift or low lift.
2. Mix design test results.
3. Certifications:
    a. Units comply with ASTM C55 and ASTM C90.
    b. Grout test results conform to ASTM C1019.
    c. Grout aggregates conform to requirements of ASTM C33, including nonreactivity.
    d. Mortar sand conform to requirements of ASTM C144.
4. Test results of Project samples from masonry unit manufacturer stating that units comply with ASTM C90. Documentation of material testing shall be one less than 1 year old.
5. Test results of proposed grout mix deign stating that units comply with ASTM C1019. Documentation of material testing shall be 1-year old or less.
6. Test reports stating aggregates for mortar meet requirements of ASTM C144.

7. Test reports or letter of certification stating aggregates for grout meet requirements of ASTM C404.
8. Letter from water repellent admixture manufacturer verifying masonry unit manufacturer's proper use of product.
9. Method and materials for removal of efflorescence.
10. Field test results to qualify materials: Grout tests in accordance with ASTM C1019.

1.03 QUALITY ASSURANCE

A. Mockups:

1. Lay up Sample panel for each type of masonry at Site.
2. Dimensions: Minimum 4 feet high by 4 feet long.
3. Use approved materials and procedures.
4. May be part of permanent construction.
5. Approved panels shall serve as basis of color, texture, bond, quality of finished joints, surface applied finishes, and for acceptance of permanent construction.
6. Demonstrate ability to keep grout isolated and in certain cells during any sequence of placement, and to demonstrate materials will be restricted to cells and bond beams intended to receive grout.
7. Construction shall show areas required to receive mortar, including webs on each side of each grouted cell to prevent grout from entering adjacent cells or courses.
8. Where bond beams are to be used, demonstrate proper placement of grout to bond beam level, and proper placement of bond beam prior to placement of grout above bond beam level.
9. Demonstrate proper use of running bond and stacked bond.
10. Compliance Requirements: For masonry finish and appearance, dimension tolerances, tolerances of construction, joint tolerances, and wall plumb tolerances, comply with the requirements and criteria of NCMA, ASTM C90, and TMS 602.1.

B. Masonry Unit Manufacturer: Qualified by manufacturer of water repellent admixture to use product.

C. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Masonry subcontractor, including masonry foreman.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.

e. Design Structural Engineer.
f. Project Architect for coating system and appearance.

2. Schedule and conduct prior to start of masonry construction.
3. Notify Engineer of location and time.
4. Agenda shall include:
   a. High lift and low lift procedures.
   b. Mortar, grout, unit, and reinforcing submittals.
   c. Types and locations of rebar splices.
   d. Joint tooling.
   e. Admixture types, dosage, performance, and redosing at Site.
   f. Mix designs and test of mix.
   g. Placement methods, techniques, equipment, consolidation, and reconsolidation.
   h. Protection procedures for environmental conditions.
   i. Other specified requirements requiring coordination.
5. Submit conference minutes as specified in Section 01330, Submittal Procedures.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Keep units and mortar/grout cementitious ingredients, including lime, dry.

PART 2 PRODUCTS

2.01 COMPRESSIVE STRENGTH OF MASONRY ASSEMBLAGE

A. Minimum 28-Day Specified Compressive Strength (f'm) of Masonry: 2,000 pounds per square inch.

2.02 CONCRETE MASONRY UNITS (CMU)

A. ASTM C90: Medium weight.

1. Net Area Compressive Strength: 2,000 pounds per square inch minimum, in accordance with TMS 602, Table 2.
   a. Water Repellent Admixture:
      1) Structural concrete masonry units in weather exposed exterior wall shall be manufactured with integral liquid polymeric admixture to provide resistance to water penetration.
      2) Manufacturers and Products:
         a) GCP Applied Technologies.; Dry-Block Block Admixture.
         b) BASF Construction; MasterPel 240.

2. Nominal Size: 16 inches long by 8 inches high by thickness shown on the Drawings.
3. Color of Units: Match existing DC2 Digester (Natural, field verify).
4. Surface Texture on Exposed Surfaces: Match existing DC2 Digester (Smooth, field verify).

B. General Concrete Masonry Unit (CMU) Requirements:

1. Furnish or cut special shapes for corners, jambs, lintels, and other areas shown or required.
2. Special units shall match color and texture of standard units.
3. Where units are placed so end of unit is exposed, such as at a corner or intersection, exposed end of that block shall have surface to match color and texture of sides of other units.
4. Furnish sound, dry, clean units free of cracks, prior to placing in structure.
5. Vertical Cells to be Grouted: Capable of alignment sufficient to maintain clear, unobstructed continuous vertical cell dimensions in accordance with TMS 602, Table 7.
6. Masonry unit size and shape shall allow for all placement patterns. Use vertical grout dams to prevent materials, such as grout, from escaping from cell being filled to adjacent cells where material is not intended to be placed.

C. Textured Concrete Masonry Units (TCMU):

1. Same type and weight as structural units.
2. Nominal Size: 16 inches long by 4 inches high by thickness shown on the Drawings.
3. Split Face: Match existing DC2 Digester accent, field verify.
4. Color of Units: Match existing DC2 Digester (Terracotta, field verify).

2.03 MORTAR MATERIALS

A. Portland Cement-Lime Mortar:

1. ASTM C270.
2. Cement: ASTM C150, Type I and Type II portland cement.
3. Lime: ASTM C207, Type S hydrated.
4. Aggregates:
   a. Non-reactive in accordance with ASTM C33, Appendix X1.
   b. Mortar: ASTM C144, sand.

B. Mortar Cement Mortar: ASTM C1329.

C. Water: Fresh, clean, and potable.

D. Water Repellent Admixture:

1. ASTM C1403.
2. Mortar for structural and textured concrete masonry units in weather exposed exterior walls shall include an integral liquid polymeric admixture to provide resistance to water penetration.
3. Manufacturer and Product:
   a. GCP Applied Technologies.; Dry-Block Mortar Admixture.
   b. BASF Corporation; MasterPel 240MA.

E. Manufacturers and Products:

1. W.R. Grace; DRY-BLOCK.
2. Harris Specialty Chemicals.
3. Axim Italcementi Group; Intrapel.
4. BASF Chemical Co.; Rheopel Admixture.

F. Mortar Color Admixture:

1. Meet the requirements of ASTM C979.
2. Manufacturer and Product: Davis Colors, Los Angeles, CA; True Tone Mortar Color.
3. Color shall be selected by Owner.

2.04 GROUT

A. Cement: ASTM C150, Type I and Type II Portland cement.

B. Fly Ash: Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618.

C. Slag Cement: In accordance with ASTM C989, Grade 100 or Grade 120.

D. Lime: ASTM C207, Type S hydrated.

E. Aggregates:

1. ASTM C476: Coarse.
2. Non-reactive in accordance with ASTM C33, Appendix X1.

F. Water: Fresh, clean, and potable.

2.05 REINFORCEMENT

A. Reinforcement: Clean and free from loose rust, scale, and coatings that reduce bond.

B. Deformed Bars: As specified in Section 03210, Steel Reinforcement.

2.06 PREFORMED CONTROL JOINTS

A. Solid rubber cross-shape extrusions as manufactured by:

1. Dayton Superior or Dur-O-WalDayton, OH; DA 2001 Control Joint Regular Rubber.
2. Hohmann and Barnard, Inc, Hauppauge, NY; #RS-Standard.

2.07 MORTAR MIXES

A. In accordance with ASTM C270, Type S and TMS Specifications.

B. Mix Method:

1. Property Method: Minimum average mortar 28-day compressive strength 1,800 pounds per square inch.

C. Mixing:

1. Machine mix in approved mixers in accordance with ASTM C270. Time addition of approved admixtures in accordance with manufacturer's instructions. Procedure used for adding it to mix shall provide good dispersion.
2. Follow manufacturer's instructions for water repellent admixture.
3. Review compatibility with other mortar admixture.

2.08 GROUT MIXES

A. Compressive Strength Property: Minimum 2,000 pounds per square inch at 28 days. Grout strength shall not exceed two times the minimum specified strength.

B. Mix Design:

1. Proportions:
   a. Design mix to meet property/strength requirements.
   b. Where fly ash or slag is included in mix, fly ash or slag content shall be a minimum of 15 percent and a maximum of 25 percent of weight of total cementitious materials.
2. Slump: 8-inch minimum, 11-inch maximum.

C. Mixing:

1. Do not use water reducers, air entrainment, plasticizing, high-range water reducers, or other non-specified admixtures in grout mixes.
2. Transit-Mixed Grout: Meet requirements of ASTM C476.

3. For high lift grouting, add approved grout expansion admixture in accordance with manufacturer's recommendations.
4. Fluid consistency suitable for placing without segregation with a slump of 8 inches to 11 inches.

2.09 WATER REPELLENT MASONRY SEALER

A. Characteristics:

1. Water-based blend of silanes and siloxanes.
2. VOC compliant.

B. Performance Requirements:

1. Water Absorption: 95 percent reduction in weight gain when tested in accordance with ASTM C140.
2. Water Repellency: 99 percent reduction in weight gain when tested in accordance with ASTM E514.

C. Manufacturers and Products:

1. W. R. Grace & Co.; Infiniseal DB Sealer.
2. BASF Construction Chemicals; Enviroseal PBT.

PART 3 EXECUTION

3.01 GENERAL

A. Meet requirements of 2021 IBC, Chapter 21 and 2016 The Masonry Society (TMS) 602, Specification for Masonry, Part 3, Execution, except as modified in this section.

B. Moisture Protection:

1. Keep units dry while stored on Site.
2. Do not wet units prior to laying.

C. Provide measures to prevent moisture from entering incomplete walls and open cells.

D. Cold Weather: Meet requirements of TMS Specification Section "Cold Weather Construction."

E. Hot Weather: Meet requirements of TMS Specification Section "Hot Weather Construction."

F. After construction during cold weather, maintain newly constructed masonry temperature above 32 degrees F for a minimum of 24 hours using TMS or other approved cold weather methods.

G. After construction and during hot weather, fog spray newly constructed masonry in accordance with TMS hot weather construction requirements.

3.02 PREPARATION

A. Concrete Foundations: Meet tolerance requirements of ACI 117 prior to starting any masonry work.

B. Prepare surface contact area of foundation concrete for initial mortar placement by removing laitance, loose aggregate, and other materials, and anything that would prevent mortar from bonding to foundation.

C. Patch or grind out-of-tolerance foundation surfaces to receive mortar prior to starting masonry work.

D. Clean reinforcement dowels and projecting embeds by removing laitance, spillage, or items that will adversely affect grout bond.

E. Prevent surface damage to foundation concrete that will be exposed to view outside of contact area.

3.03 LAYING MASONRY UNITS

A. General:

1. Finish Tolerances (Measured on Interior Surfaces): Meet requirements of “Site Tolerance” requirements of Part 3, Execution, of the TMS Specifications.
2. Place units with chipped edges or corners such that chipped area is not exposed to view.

B. Wall Units:

1. General:
   a. If necessary to move a unit after once set in-place, remove from wall, clean, and set in fresh mortar.
   b. Toothing of masonry units is not permitted.

2. Running Bond:
   a. Unless otherwise shown, lay up walls in straight, level, and uniform courses using a running bond pattern.
   b. Place units for continuous vertical cells and mortar joints to prevent materials, such as grout, from escaping from cell being filled to adjacent cells where material is not intended to be placed.
   c. Corners: Lay standard masonry bond for overlapping units and grout solid.
3. Special Shapes:
   a. Provide and place such special units as corner block, doorjamb block, lintel block fillers, and similar blocks as may be required.
   b. Use required shapes and sizes to work to corners and openings, maintaining proper bond throughout wall.

3.04 BUILT-IN ITEMS

A. Position door frames, windows, vents, louvers, and other items to be built in wall, and construct wall around them.

B. Install masonry anchors to secure items to wall.

C. Fill spaces around items with grout except use mortar at mortar joints.

D. Do not place electrical, instrumentation, or water conduits in a cell containing parallel reinforcement, unless approved in writing by Engineer. Additionally, pipes, sleeves, and conduits shall meet requirements of TMS 402/ACI 530/ASCE 5, Building Code Requirements for Masonry Structures (MSJC Code) and MSJC specification construction requirements.

3.05 MORTAR JOINTS

A. General:

1. Meet masonry erection requirements of MSJC, Part 3, Execution, 3.3B.
2. As units are laid, remove excess mortar from grout space of cells to be filled. Final grout space, including any remaining mortar projections, shall be as required by MSJC Table “Grout Space Requirements.”
3. Place mortar before initial setting of cement takes place. Retemper only as required for it to remain plastic. Retempering of colored mortar is not allowed.
4. Remove mortar containing water repellent admixture from face of masonry before it sets.

B. Exposed Joints:

1. Tool joints exposed to view after final construction, unless otherwise noted or shown.
2. Cut joints flush and as mortar takes its initial set; tool to provide a concave joint.
3. Perform tooling with tool that compacts mortar, pressing excess mortar out.
4. Perform tooling when mortar is partially set, but still sufficiently plastic to bond rather than dragging it out.
5. Rake out joints that are not tight at time of tooling, point, and then tool.
6. Rake and tool joints at split-face surfaces, interior and exterior.

C. Concealed Joints: Strike flush with no further treatment required.

3.06 CONTROL JOINTS

A. Preformed Control Joints:

1. Omit mortar from vertical joints.
2. Place in units fabricated to receive rubber control joint material as wall is built.
3. After wall is grouted, cured, and cleaned, install backing rod and sealant as specified in Section 07900, Joint Sealants.
4. Place and tool sealant to match depth of typical joint.

3.07 REINFORCING

A. Foundation Dowels:

1. Locate first foundation dowel at end of wall in center of first cell; typically 4 inches from end of wall.
2. Locate at each side of control joints and openings and below beam and joist seats, and then locate at maximum required spacing between these bars.
3. Size, number, and location of foundation dowels shall match all typical and additional vertical wall reinforcing, unless otherwise noted.
4. When foundation dowel does not line up with vertical core, do not slope more than 1 horizontal to 6 vertical to bring it into alignment.

B. Vertical Reinforcing:

1. Use deformed bars.
2. Hold in position near ends of bars by wire ties to dowels or by reinforcing positioners.

3. For high lift grouting, hold in position at maximum intervals of 160 bar diameters by reinforcing positioners.
4. Lap reinforcing bars as shown or approved.
5. Wire tie splices together.
6. Minimum Bar Clearance: 1/2-inch from masonry for coarse grout, from formed surfaces, and from parallel bars in same grout space.

C. Horizontal Reinforcing:

1. Use deformed bars.
2. Lay on webs of bond beam units and place as wall is built. Increase web depth to ensure 1/2-inch cover over top of rebar.
3. Lap reinforcing bars where spliced and wire tie together.
4. Minimum Bar Clearance: 1/2-inch from masonry for coarse grout, from formed surfaces, and from parallel bars in same grout space.
5. Terminate reinforcing bars 2 inches clear from control joints except horizontal bars at roof and floor courses shall be continuous through joints.

3.08 MORTAR PRODUCTION

A. Mix bulk materials in accordance with MSJC Specification.

B. Mix prebagged materials with water to produce a workable consistency.

C. Remix or retemper to maintain workability. Discard mortar that has begun to stiffen or is not used within 2-1/2 hours after initial mixing.

3.09 GROUT PLACEMENT

A. Do not mix, convey, or place with equipment constructed of aluminum.

B. Secure vertical and horizontal reinforcement, ties, bolts, anchors, and other required embedments in place; inspect and verify before placing grout.

C. Grout beams over openings in one continuous operation.

D. Maintain vertical alignment in accordance with TMS 602, Section 3.4:

1. Place grout within 1-1/2 hours of addition of water to mix.
2. Use reinforcing positioners to secure vertical reinforcement.

E. Grouting Requirements:

1. Solid Grout All Walls:
   a. Slump: 8 inches to 11 inches.
   b. Do not start grouting until wall mortar has cured for 24 hours, minimum.
2. Fully embed horizontal steel with grout in an uninterrupted pour.
3. Do not construct wall more than one course above top of grout pour prior to placing grout.
4. Partial Grouting Requirements:
   a. Fill cells containing reinforcing steel, anchor bolts, and other embedded items as shown with grout.
   b. Construct cells to be filled to confine grout within cell.
   c. Cover tops of unfilled vertical cells under a bond beam with metal lath to confine grout fill to bond beam section.
   d. Form horizontal construction joints between pours by stopping grout pour 1-1/2 inches below a mortar joint, except at a bond beam; stop pour 1/2-inch below top of masonry unit.

F. Vibration:

1. Use internal “pencil” type, low energy vibrator to thoroughly consolidate grout and reduce amount of air voids. Do not use concrete vibrators.
2. After initial water loss and settlement has occurred, but before it has taken any set, reconsolidate grout.
3. Waiting period for reconsolidation will vary depending upon weather conditions and block absorption rates, but under “normal” weather conditions with average masonry units the waiting period should be between 30 minutes and 60 minutes.

G. Cleanouts:

1. Construct in accordance with TMS specification.
2. Provide for grout pours heights over 5 feet 4 inches.
3. Provide of sufficient size to permit cleaning of cell, positioning of reinforcing, and inspection at bottom of every vertical cell containing reinforcing and maximum of 32 inches on center.
4. Location: Concealed from view after final construction, unless otherwise approved by Engineer.
5. After wall has been inspected and approved and prior to grouting, cap cleanouts in a manner that will seal them from grout leakage and provide a flush finish.

3.10 WATER REPELLENT MASONRY SEALER

A. Remove efflorescence prior to applying water repellents. Dispose of waste generated.

B. Apply to exposed exterior concrete masonry walls.

C. Repoint loose, cracked, or disintegrating mortar at least 7 days prior to application. Ensure joint sealants and caulking are fully cured and wall surfaces are clean, dry, and free of chemical cleaners, efflorescence, dirt, oils, mortar smears, and other surface contaminants.

D. Follow manufacturer's recommendations for weather conditions during application.

E. Test a 5-foot by 5-foot wall area to ensure proper coverage, desired water repellency properties, and desired surface appearance when sealer is fully dried.

F. Apply with spray, brush, or roller following manufacturer's recommendations, at a coverage rate of 50 square feet to 150 square feet per gallon, as determined by testing. Use two-coat application where recommended by manufacturer.

3.11 FIELD QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

C. Masonry shall be tested by independent testing agency, retained by Contractor and approved by Engineer.

D. Provide adequate facilities for safe storage and proper curing of masonry prisms, mortar samples, and grout samples, as applicable, onsite for first 24 hours, and for additional time as may be required before transporting to test lab.

E. Masonry Testing:

1. Masonry strength shall be determined using unit strength method as shown.
2. Unit Strength Method:
   a. Method and frequency for mortar, grout, and masonry unit sampling and testing shall be as shown.
   b. Provide masonry units for test samples required.

F. Corrective Action:

1. If compressive strength tests made prior to construction of permanent structure fail to meet Specifications, adjustments shall be made to mix designs for mortar, or grout, or both, as needed to produce specified strength.
2. If strength tests performed on materials representative of in-place construction fail to meet Specifications, prisms or cores shall be cut from constructed walls in sufficient locations to adequately determine strength in accordance with TMS.

3.12 CLEANING

A. Immediately after completion of grouting, clean masonry surfaces of excess mortar, grout spillage, scum, stains, dirt, and other foreign substances using clean water and fiber brushes.

B. Clean walls not requiring painting or sealing so there are no visible stains.

3.13 PROTECTION OF INSTALLED WORK

A. Do not allow grout and mortar stains to dry on face of exposed masonry.

B. Protect tops of walls at all times. Cover tops of walls with waterproof paper when rain or snow is imminent and when the Work is discontinued.

C. Adequately brace walls until walls and roof are completed.

D. Provide sufficient bracing to protect walls against damage from elements, including wind and snow.

E. Protect masonry against freezing for minimum 72 hours after being laid.

F. Protect masonry from damage until final acceptance of the Work. Damaged units will not be accepted.

END OF SECTION

SECTION 04813
MASONRY VENEER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   c. C90, Standard Specification for Loadbearing Concrete Masonry Units.
   d. C91, Standard Specification for Masonry Cement.
   e. C144, Standard Specification for Aggregate for Masonry Mortar.
   f. C150/C150M, Standard Specification for Portland Cement.
   g. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   h. C216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale).
   i. C270, Standard Specification for Mortar for Unit Masonry.
   j. C979/C979M, Standard Specification for Pigments for Integrally Colored Concrete.
   k. D1056, Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
   l. E2178, Standard Test Method for Air Permeance of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s product information for each different item specified.
   b. Mix designs for mortar.

2. Samples:
   a. Full-size units for each different exposed masonry unit required showing full range of exposed color, texture, and dimensions to be expected in completed construction. New concrete masonry units to match existing units associated with existing Digester 1 and Digester 2.
      1) Include size variation data verifying that actual range of sizes for masonry falls within ASTM C216 dimension tolerances for masonry where modular dimensioning is indicated.
   b. Accessories embedded in masonry.

B. Informational Submittals:

1. Experience record of mortar color pigment proposed for use.
2. Manufacturer's certificate of compliance for masonry units specified herein.
3. Method and materials for removal of efflorescence.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: For masonry construction meet requirements of the International Building Code and as supplemented by these Specifications.

B. Mockups: Lay up a Sample panel for each type of masonry at the Site to simulate proposed concrete masonry units, bond pattern and method of finishing joints. Make Sample panels 4 feet high and 4 feet long. Remove mockup after acceptance of permanent masonry Work. Acceptable Sample panel serves as a basis of color, texture, pattern, and workmanship for acceptance of the permanent construction.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection:

1. Store all masonry materials off ground and protected from precipitation.
2. Protect veneer materials from mud splatters and staining.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not lay masonry when ambient temperature is below 32 degrees F on a rising temperature or below 40 degrees F on a falling temperature, or when there is a probability of such conditions occurring within 48 hours, unless express approval of Engineer is obtained. In such case, make special provisions for heating materials and protecting finished Work. Protect masonry against freezing for a minimum of 48 hours after being laid. Protect tops of walls from precipitation at all times. Cover with waterproof paper when rain or snow is imminent and the Work is discontinued.

B. Humidity: Protect masonry construction from direct exposure to wind and sun when erected in an ambient air temperature of 99 degrees F (37 degrees C) in the shade with relative humidity less than 50 percent.

PART 2 PRODUCTS

2.01 MASONRY UNITS

A. Color, Texture, and Pattern: Match existing digesters on the campus.

1. Concrete Masonry Unit Veneer:
   a. ASTM C90: Medium weight.
   b. Nominal Size: 16 inches long by 8 inches high by thickness shown on the Drawings.
   c. Compressive Strength: 1,900 pounds per square inch minimum, in accordance with ASTM C90, Table 2.
   d. Color of Units: As indicated on the Drawings and to match existing Digesters.
   e. Surface Texture on Exposed Surfaces: Ground-Face and Split-Face as indicated on the Drawings.

2.02 MORTAR MATERIALS

A. Masonry Cement: ASTM C91, low alkali content (0.03 percent maximum).

B. Portland Cement: ASTM C150, Type I, low alkali content (0.60 percent maximum).

C. Lime: ASTM C207, Type S.

D. Mortar: ASTM C270, Type S. Consisting of one part portland cement, from 1/4 part to 1/2 part lime putty or hydrated lime, and clean well-graded sand in the proportion of 3 times the sum of the cementitious material; or 1/2 part portland cement, one part masonry cement, and clean well-graded sand in the proportion of three times the sum of the cementitious material.

1. No antifreeze liquid, salts, or other substances are allowed to lower freezing point. No calcium chloride is allowed in mortar.

E. Tuck-Pointing Mortar: Prehydrated Type N, one part portland cement, one part Type S hydrated lime, and six parts sand, by volume.

F. Sand: ASTM C144, in addition not less than 5 percent passes the No. 100 sieve.

G. Water: Fresh, clean, and free of deleterious acids, alkalies, chlorides, and organic materials.

2.03 MORTAR PREPARATION

A. Place one-half the water and aggregate in operating mixer; add cement; add remaining aggregate and water and mix for at least 2 minutes. Add lime and continue mixing as long as needed to secure a uniform mass, but no less than 3 minutes after the addition of lime. Time the addition of admixture in strict accordance with manufacturer’s instructions and the procedure used for adding it to the mix shall provide good dispersion.

B. Mix mortar in machine with mixing drums clean and free of debris and dried mortar. Use mortar before the initial setting of the cement has taken place. Do not retemper mortar in which the cement has started to set.

C. Retemper mortar boards by adding water within a basin formed with the mortar and the mortar reworked into the water. Dashing or pouring water over mortar and retempering of harsh, nonplastic mortar is not permitted.

2.04 MASONRY CONTROL JOINTS

A. ASTM D1056, closed cell neoprene sponge, 3 inches wide by 3/8-inch thick.

2.05 COMPRESSIBLE PADS

A. ASTM D1056, closed cell neoprene sponge, 3 inches wide by 1/4-inch thick, with pressure sensitive adhesive applied on one side.

2.06 WATER BARRIER

A. Water barrier, fluid applied, one component, vapor permeable membrane, cures on concrete surfaces to form a resilient, monolithic, fully-bonded elastomeric sheet, 40 mils minimum dry thickness, meeting requirements of ASTM E2178 for air permeance.

B. Manufacturers and Products:

1. Grace, Perma-A-Barrier Liquid VP.
2. Hohmann and Barnard, Inc.; Textroflash Liquid VP.

2.07 THROUGH-WALL FLASHING

A. EPDM with Stainless Steel Drip Plate:

1. 40-mil thick EPDM with manufacturer’s recommended adhesive and termination bar.
2. Drip plate, stainless steel, ASTM A240/A240M, 3 inches wide, with factory applied adhesive for bond to EPDM.
3. Manufacturers and Products:
   a. Hohmann and Barnard, Inc.; EPRA-Max with DP-FTSA.
   b. Wire Bond; EPDM thru-wall flashing and 4165 drip edge.

2.08 VENEER ANCHORS

A. Seismic Anchors:

1. Dovetail Slots and Seismic Anchors (Veneer to Concrete Backing):
   a. 16-gauge steel anchor slots with mating.
   b. Galvanized in accordance with ASTM A153/A153M, 16-gauge steel anchor tie. Tie length as required by 1-1/4-inch minimum width, swagged to engage 9-gauge horizontal wire.
   c. Manufacturer and Product: Hohmann and Barnard, Inc.; 305 Slot and 303-SV Anchor with Wire.

2.09 CAVITY WEEPS

A. Weep Vents:

1. Honeycomb, polypropylene; 3/8-inch by size of head joint; match color of mortar.
2. Manufacturers and Products:
   a. Hohmann and Barnard; QV Quadro Vent.
   b. Wire-Bond; 3601 Cell Vent.

2.10 MASONRY ACCESSORIES AND ANCILLARY MATERIALS

A. Water Repellent: As specified in Section 07190, Water Repellents.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other specific conditions, and other conditions affecting performance of masonry veneer.

B. Examine rough-in and built-in construction to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.02 WATER BARRIER

A. Cleaning of Substrate:

1. Thoroughly clean surfaces to receive membrane following membrane manufacturer's recommendations.
2. Treat as necessary to remove laitance, loose material on surface, grease, oil, and other contaminants that will affect bond of the membrane.
3. Vacuum clean or clear water wash surfaces and allow to dry completely.

B. Fill voids and control joints with sealant and overcoat with nonflow membrane material. Fill or coat visible shrinkage cracks to minimum 2 inches either side of crack.

C. Follow manufacturer's directions for application including limitations because of weather, temperature, and concrete cure time. Apply by brush or spray following manufacturer's recommended coverage and coating rates.

3.03 GENERAL INSTALLATION

A. Provide or cut special shapes for corners, jambs, lintels, and other areas as shown or as required. Match color and texture of standard units.

B. Cut masonry units with motor-driven saws to provide clean, sharp, unchipped edges. Cut units as required to provide continuous pattern and to fit adjoining construction. Use full-size units without cutting where possible.

C. Matching Existing Masonry: Match coursing, bonding, color, and texture of new masonry with existing masonry as specified and shown on the Drawings.

3.04 CONCRETE MASONRY VENEER WALL CONSTRUCTION—GENERAL

A. Mortar Beds: Lay concrete masonry with full mortar coverage on horizontal and vertical joints. Rock closures into place with head joints thrown against two adjacent units in-place. Do not pound corners or jambs to fit stretcher units after setting in-place. Where adjustment to corners or jambs must be made after mortar has started to set, remove mortar and replace with fresh mortar.

B. Horizontal and Vertical Face Joints:

1. Nominal Thickness: 3/8-inch.
2. Construct uniform joints.
3. Shove vertical joints tight.
4. Tool joints concave in exposed surfaces when thumbprint hard using jointing tool.
5. Flush cut all joints not tooled.
6. Fill horizontal joints between top of masonry partition and underside of concrete beams with mortar.

C. Tuck-Point Joints:

1. Rake mortar joints to a depth of 1/2-inch to 3/4-inch.
2. Saturate exposed joints with clean water.
3. Fill joints solidly with pointing mortar.
4. Tool joints to match existing.

D. Movement Joints: Keep clean of all mortar and debris.

E. Masonry Control Joints:

1. Provide continuous vertical control joints in masonry as shown on the Drawings.
2. Omit mortar from vertical joints. Place control joint material as wall is built.

F. Through-Wall Flashing:

1. Place flashing on bed of mortar.
2. Lap cross joints of through-wall flashing at least 2 inches.
3. Extend flashing beyond exterior face of wall and provide drip edge.
4. Cover flashing with mortar.

G. Flashing: Clean surface of masonry smooth and free from projections that might puncture, gouge, or otherwise damage flashing material.

H. Weep Vents: Provide weep vents in head joints in first course immediately above all flashing leaving head joint free and clean of mortar.

1. Maximum Spacing: 24 inches OC.
2. Keep weep holes and area above flashing free of mortar droppings.

3.05 CONCRETE MASONRY UNIT VENEER INSTALLATION

A. General: Do not install cracked, broken, or chipped masonry units exceeding ASTM C216 allowances. Thoroughly wet concrete masonry just before laying except in freezing weather where concrete masonry are laid dry. Prewetting may also be omitted if the concrete masonry at the time of laying has a rate of absorption not exceeding 0.025-ounce of water per square inch of surface after being placed in 1/8-inch of water for 1-minute.

1. Coordinate installation with backup walls, through wall flashing, and other construction. Use masonry saws to cut and fit exposed units. Lay concrete masonry plumb, true to line, with level courses accurately spaced, and do not furrow bed joints.
2. Finish horizontal run by racking back in each course; toothing not permitted. Adjust all units to final position while mortar is soft and plastic. If units are displaced after mortar has stiffened, remove, clean joints and units of mortar, and relay with fresh mortar.
3. Bond unexposed units in wythe by lapping a minimum of 2 inches. Adjust shelf angles to keep Work level at proper elevation. Provide pressure relieving joints by placing a continuous compressible pad under the shelf angle.
4. When joining fresh masonry to set or partially set masonry:
    a. Remove loose concrete masonry and mortar.
    b. Clean and lightly wet exposed surface of set masonry prior to laying fresh masonry.

B. Anchoring:

1. Anchor masonry veneer to concrete structural backing wall as specified, shown on the Drawings, and in conformance to the International Building Code.
2. Keep space free of mortar or other rigid material to permit differential movement between backing wall and masonry.
3. Attach veneer to backing with anchor ties.
    a. Use one anchor tie for each 1.77 square feet of wall area.
    b. Maximum Space between Adjacent Ties:
        1) Vertically: 24 inches.
        2) Horizontally: 32 inches.

c. Embed ties at least 2 inches in horizontal joint of veneer. Engage or swag a continuous horizontal wire into each anchor tie.
d. Provide additional ties at openings:
   1) Maximum Spacing Around Perimeter: 24 inches.
   2) Install within 12 inches of opening.

C. Pattern: Lay concrete masonry in running bond to match existing Digesters on campus.

3.06 CLEANING

A. Cleaning Agents:

1. Job-Mixed Detergent Solution: Solution of trisodium phosphate (1/2 cup dry measure) and laundry detergent (1/2 cup dry measure) dissolved in 1-gallon of water.

B. Follow masonry and mortar color manufacturer's recommendations for use of cleaning agents.

C. Application:

1. Thoroughly wet surface of masonry on which no efflorescence appears before using cleaning agent.
2. Scrub with acceptable cleaning agent.
3. Immediately rinse with clean water.
4. Work small sections at a time.
5. Work from top to bottom.
6. Protect sash, metal lintels, and other materials, which may corrode when masonry is cleaned with acid solution.
7. Remove efflorescence in accordance with masonry manufacturer's recommendations.

D. Leave Work area and surrounding surfaces clean and free of mortar spots, droppings, and broken masonry.

3.07 FIELD QUALITY CONTROL AND QUALITY CONTROL

A. At least once a week while installation of masonry veneer is in progress, take mortar Samples for testing. Continue on that basis for duration of installation of masonry veneer at discretion of Engineer.

B. Take Samples in accordance with ASTM C270.

C. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan in Supplement located at end of Section 01451, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

3.08 WATER REPELLENT

A. As specified in Section 07190, Water Repellents.

3.09 PROTECTION

A. Wall Covering:

1. During erection, cover top of wall with strong waterproof membrane at end of each day or shutdown and as follows:
   a. Cover partially completed walls when Work is not in progress.
   b. Extend cover minimum of 24 inches down both sides.
   c. Hold cover securely in-place.

B. Protect sills, ledges, and offsets from mortar drippings or other damage during construction. Remove misplaced mortar immediately. Protect face materials against staining. Protect the door jambs and corners from damage during construction.

END OF SECTION

SECTION 05020
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 DEFINITIONS

A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.

C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete Anchors:
   a. Manufacturer’s product description and installation instructions.
   b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
2. Passivation method for stainless steel members.

1.03 QUALITY ASSURANCE

A. Qualifications: Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program, or equivalent.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Package stainless steel items in a manner to provide protection from carbon impregnation.

B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8 A193/A193M, Grade B7
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.

B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
   b. DeWalt/Powers Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).

C. Self-Tapping Concrete Screw Anchors:

1. Manufacturers and Products:
   a. DeWalt/Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
   b. DeWalt/Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
   c. DeWalt/Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
   d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
   e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).

D. Adhesive Anchors:

1. Threaded Rod:
   a. Diameter as shown on the Drawings.
   b. Length as required to provide minimum depth of embedment indicated and thread projection required.
   c. Clean and free of grease, oil, or other deleterious material.
2. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
3. Packaging and Storage:
   a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
   b. Store adhesive on pallets or shelving in a covered storage area.
   c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
   d. Dispose of When:
      1) Shelf life has expired.
      2) Stored other than in accordance with manufacturer's instructions.
4. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 V3 (ESR-4868).
   b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-3G Epoxy Adhesive Anchors (ESR-4057), or AT-3G Adhesive Anchors (ESR-5026).
   c. DeWalt/Powers Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

PART 3 EXECUTION

3.01 CONCRETE ANCHORS

A. Begin installation only after concrete to receive anchors has attained design strength.

B. Locate existing reinforcing with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing.

C. Install in accordance with written manufacturer's instructions.

D. Provide minimum embedment, edge distance, and spacing as indicated on the Drawings.

E. Use only drill type and bit type and diameter recommended by anchor manufacturer.

F. Clean hole of debris and dust per manufacturer's requirements.

G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

H. Adhesive Anchors:

1. Unless otherwise approved by Engineer and adhesive manufacturer:
   a. Do not install adhesive anchors when temperature of concrete is below 40 degrees F or above 100 degrees F.
   b. Do not install prior to concrete attaining an age of 21 days.
   c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
   d. Do not disturb anchor during recommended curing time.
   e. Do not exceed maximum torque as specified in manufacturer's instructions.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01451, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

3.03 FASTENER SCHEDULE

A. Unless indicated otherwise on the Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
2. All Others		
All service uses and locations	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on all stainless steel threads.

C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05050
WELDING

PART 1 GENERAL

1.01 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

1. Contractor's Welding Inspector: Contractor's CWI acts for, and on behalf of, the Contractor for all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes. This type of Quality Control Inspection is not classified as Special Inspection.
2. Verification Inspector: This independent inspection is the prerogative of the Owner, who may employ their own, independent CWI, or waive this supplementary, independent CWI inspection.

C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. Special Inspection: Nondestructive weld examination including MT, PT, UT, and RT.

1. Special Inspection personnel report to, and are retained by the Owner, except as noted below:
   a. Contractor and fabricator are required to complete nondestructive weld examinations for welded steel tanks, welded steel pipe, and process piping.
2. See additional requirements in Section 01451, Special Inspection, Observation, and Testing.

J. RT: Radiographic Testing.

K. UT: Ultrasonic Testing.

L. VT: Visual Inspection or Testing.

M. WPQ: Welder or Welding Operator Performance Qualification Record.

N. WPS: Welding Procedure Specification.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop and field WPSs and PQRs.
   b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
   c. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
      1) Show on Shop Drawings, or on a weld map, complete information regarding base metal ASTM specifications, and location, type, size, and length of welds.
      2) Identify WPS to be used, and NDE requirements in tail of welding symbol.
      3) Clearly distinguish between shop and field welds.
      4) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
      5) Welding and NDE Symbols shall be in accordance with AWS A2.4. Welding terms and definitions shall comply with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency NDE inspector credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms provided in referenced welding codes.

1.03 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex J Forms) for shop or field welding; or ASME BPVC SEC IX (Form QW-482 and Form QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex J Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require prior approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.04 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Fabricator’s CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPSs.
3. Monitor welder performance and conformance with approved WPQs.
4. Inspect weld joint fit-up and perform in-process inspections.
5. Provide 100 percent visual inspection of completed welds.
6. Coordinate with nondestructive testing personnel and review NDE results.
7. Maintain records and prepare reports documenting results of CWI VT and required NDE complies with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Quality Control Inspection:

1. All Welds: 100 percent VT by Contractor's CWI.
2. Acceptance Criteria:
   a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 10.24.
   b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
   c. Stud Connections: AWS D1.1/D1.1M, Paragraph 9.8.1.

B. Nondestructive Testing Requirements:

1. NDT frequency shall be as specified below, as required by referenced fabrication or welding codes, or as specified in the attached table. In case there is a conflict, the higher frequency level of NDT shall apply.
   a. Nontubular Connections:
      1) CJP Butt Joint Groove Welds: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.
      2) All Other CJP Groove Welds: 10 percent random UT.
      3) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
   b. Tubular Connections:
      1) CJP butt joint groove welds made from one side without backing: 100 percent RT or UT in accordance with AWS D1.1/D1.1M, Paragraph 10.25.2 requirements.
      2) CJP Butt Joint Groove Welds made with back-gouging: 10 percent random RT.
      3) CJP Butt Joint Groove Welds made with backing and other butt joint groove welds that cannot be readily radiographed: 10 percent random UT.
      4) All Other CJP Groove Welds: 10 percent random UT.
      5) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.

2. NDT Procedures and Acceptance Criteria:
   a. Nontubular Connections:
      1) RT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part E. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.12.1.
      2) UT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part F. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.13.1.
      3) PT and MT:
         a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
         b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
   b. Tubular Connections:
      1) RT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.27, and Paragraph 10.28.
      2) UT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.26, and Paragraph 10.29.
      3) PT and MT:
         a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
         b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 10.24.

3.03 FIELD QUALITY CONTROL

A. The Contractor’s CWI shall be present whenever field welding is being done and shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor welder performance and conformance with approved WPQs.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds in accordance with Paragraph Quality Control Inspection.
6. Coordinate with nondestructive testing personnel and review test results.
7. Maintain records and prepare reports confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal have been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Welding and Nondestructive Testing Table.

END OF SECTION

Welding and Nondestructive Testing						
Specification Section	**Governing Welding Codes or Standards**	**Submit WPS**	**Submit WPQ**	**Onsite CWI Required?**	**Submit Written NDT Procedure Specifications**	**NDT Requirements**
05410 Structural Metal Stud Framing	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.3/1.3M, Structural Welding Code—Sheet Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05410
05500 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum or AWS D1.6/D1.6M, Structural Welding Code—Stainless Steel	Yes	Yes	Yes	Yes	100 percent VT; also see Section 05500
05516 Aluminum Railings	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum	No	No	No	No	100 percent VT; also see Section 05516 Aluminum Railings
05530 Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum	No	No	No	No	100 percent VT; also see Section 05530
15200 Process Piping—General	ASME BPV Code, Section IX; and ASME B31.3 Normal Fluid Service Category	Yes	Yes	Yes	Yes	100 percent VT and 5 percent RT; also see Section 15200

SECTION 05 41 00
STRUCTURAL METAL STUD FRAMING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Iron and Steel Institute (AISI):
   a. Specification for the Design of Cold-Formed Steel Structural Members.
   b. Cold-Formed Steel Design Manual.
   c. Design Guide for Cold-Formed Steel Trusses.
   d. Fasteners for Residential Steel Framing.
2. American Welding Society, Inc. (AWS):
   a. C1.1, Recommended Practices for Resistance Welding.
   b. C1.3, Recommended Practices for Resistance Welding Coated Low Carbon Steels.
   c. D1.3, Structural Welding Code-Sheet Steel.
3. ASTM International (ASTM):
   a. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
   b. A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Structural Tubing in Rounds and Shapes.
   c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   d. A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   e. C954, Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 inches (0.84 mm) to 0.112 inches (2.84 mm) in Thickness.
   f. C955, Standard Specification for Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases.
4. Center for Cold-Formed Steel Structures (CCFSS): Technical Bulletin, Vol. 2, No. 1, February 1993, Screw Connections.
5. International Code Council (ICC): Evaluation Reports for Cold-Formed Steel Framing and Fasteners.

1.02 SUBMITTALS

A. Action Submittals:

1. Plan and elevation views of all metal framing systems, including location and framing of all openings.
2. Anchorage and bracing with detailed design drawings sealed by a civil or structural engineer registered in the State of Oregon, as required by Section 01612, Anchorage and Bracing.
3. Material specifications, member sizes, and properties.
4. Details of track, web stiffeners, stud bracing, blocking, bridging, and other members as required to provide a complete installation.
5. Details of connections including welding, mechanical fasteners, and accessory items.
6. Installation and erection instructions, including sequence of operations and requirements for temporary bracing and bridging.

B. Informational Submittals:

1. Anchorage and bracing calculation sealed by a civil or structural engineer registered in the State of Oregon, as required by Section 01612, Anchorage and Bracing.
2. Manufacturer’s installation requirements.
3. Welding Procedures, Qualifications, and Inspection Report: As specified in Section 05050, Welding.
4. Operation manuals for mechanical fastener installation tools.

1.03 QUALITY ASSURANCE

A. General: For member section properties, meet requirements of AISI, Specification for the Design of Cold-Formed Steel Structural Members.

B. Qualifications for Welding: As specified in Section 05050, Welding.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver to Site in bundles marked with name of manufacturer, section type, thickness, grade of material, and length.

B. Store bundles on wood blocking, flat and off ground, to keep clean and to prevent any damage or permanent distortion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide size and type of members as required by design and field coordinated with existing conditions.

B. Sheet Steel: ASTM A653/A653M, with G-60 galvanized coating.

C. Cold-Formed Members and Accessories: ASTM C955.

D. Dimensions and Properties: Calculate section properties in accordance with AISI Cold-Formed Steel Design Manual.

2.02 STUDS

A. Material:

1. ASTM A653/A653M, Structural Steel (SS) Grade 33, or High-Strength Low-Alloy Steel (HSLAS), Type A or Type B, Grade 50.
2. Section: Type, size, and thickness as indicated on the Drawings.
3. Flanges: Stiffened with return lip.
4. Webs:
   a. Studs: Punched.

B. Accessories:

1. Track: Size as required to fit over studs, same thickness as stud material, unpunched.
2. Blocking, Bridging, and Fire Stops: Same depth as studs, 0.0566-inch minimum design thickness, unpunched.
3. Bracing Straps, Angle Bracing, Clip Angles: Size and thickness as indicated on the Drawings.
4. Mounting Plates: 0.0566-inch minimum design thickness by 8 inches by 18 inches.
5. Accessories shall be from same manufacturer as studs.

C. Manufacturers and Products:

1. AMS, Los Angeles, CA; Angeles Metal Systems.
2. Clark Steel, Middleton, OH; Steel Framing Systems.
3. Dale Industries; Dearborn, MI; Dale/Incor Steel Framing.
4. Dietrich Industries, Pittsburgh, PA; Lightgauge Metal Framing Products.
5. Knorr Steel Framing Systems, Salem, OR; Light Gauge Steel Framing.

6. Marino/Ware, South Plainfield, NJ; Stud-Rite Lightweight Steel Framing Systems.
7. Unimast Incorporated, Schiller Park, IL; Steel Framing Systems.

2.03 MECHANICAL FASTENERS

A. Self-Drilling Screws:

1. Self-drilling, self-tapping screws with hexagonal washer head and corrosion-resistant finish.
2. Manufacturers and Products:
   a. ITW Buildex, Itasca, IL; ICH Traxx Self-Drilling Fasteners with Climaseal Coating and Autotraxx Standup Installation Tool.
   b. Hilti, Inc., Tulsa, OK; Kwik-Pro HWH Self-Drilling Screws with Kwik-Cote Treatment and Kwik-Tapper Screwdriver.

B. Powder-Driven Fasteners:

1. Knurled shank, minimum 1/2-inch diameter steel washer, corrosion-resistant coating.
2. Pin diameter and length to suit deck type and flange thickness of steel support member.
3. Manufacturers and Products:
   a. ITW Buildex, Itasca, IL; Buildex BX14 pins with yellow dichromate galvanizing and BX900 Installation Tool.
   b. Hilti, Inc., Tulsa, OK; ENP-series fasteners with electroplated zinc coating and DX-750 Installation Tool.

2.04 CONCRETE ANCHORS

A. Drilled anchors, size and type as shown on the Drawings and as specified in Section 05500, Metal Fabrications.

2.05 PREFABRICATION

A. Structural wall framing panels may be prefabricated prior to erection.

B. Prefabricated assemblies shall be not more than 1/8-inch out of square within length of assembly and shall be braced against racking. Use jig templates for layout and fabrication.

C. Protect prefabricated panels from damage during handling.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect all prefabricated assemblies and repair any damage.

B. Examine bearing support surfaces for compliance with requirements for installation tolerances and other conditions affecting performance of metal framing systems.

C. Provide smooth level bearing surfaces for bottom track of load-bearing walls.

D. Clean all member and bearing surfaces that will be in contact after assembly.

3.02 INSTALLATION

A. General:

1. Install framing systems as indicated on the Drawings, complete and in accordance with manufacturer's recommendations.
2. Provide temporary bracing for support of all construction loads until framing system is installed complete with sheathing or decking.
3. Install framing in true line, plumb, level, and in proper alignment.
4. Cut ends of framing members with saw or shear to bear uniformly against abutting members. Flame cutting is not permitted.
5. All structural framing members shall be full-length without splices, unless indicated otherwise.
6. Fasten members together in accordance with AISI, Cold-Formed Steel Design Manual, Part IV, Connections. Wire tying is not permitted.

B. Stud Bearing Walls:

1. Secure bottom track to floor slab with concrete anchors as indicated on the Drawings.
2. Seat studs squarely and firmly within track before securing with fasteners. Gap between end of stud and track shall be less than 1/16-inch.
3. Install studs with spacing as shown and not more than 2 inches from abutting walls.
4. Provide double studs at jambs of openings wider than stud spacing.
5. Provide triple studs at corners and at jambs of openings wider than 48 inches, unless indicated otherwise.
6. Track shall be continuous. Center splices between studs and splice with stud section full length between studs.
7. Frame wall penetrations for pipes and ducts larger than stud spacing to avoid cutting structural members.

8. Fire stop stud walls and partitions with unpunched blocking full width of stud at midpoint or where required for nailers, in conformance with applicable building code.
9. Provide blocking for support of mechanical items.
10. Do not remove the web knockouts within 10 inches of either end of load-bearing studs.
11. Provide bracing straps with gusset plates and anchor holddown assemblies where indicated on the Drawings.
12. Tolerances:
    a. Stud Plumbness: 1/8-inch in 10 feet.
    b. Stud Spacing: Plus or minus 1/8-inch.

3.03 FASTENERS

A. Self-Drilling Screws:

1. Install in accordance with manufacturer's written instructions and with special installation tool.
2. Screw type, diameter, and length shall be in accordance with AISI, Fasteners for Residential Steel Framing, minimum two screws per connection unless indicated otherwise.
3. Use clamp to hold members together. Drive screw from lighter to heavier gauge, to allow plies to be pulled together without stripping metal. Do not over torque. A minimum of three exposed threads shall extend through steel.
4. Minimum screw spacing, end distance, and edge distance shall be 3 diameters.

B. Powder-Driven Fasteners:

1. Use only for connecting cold-formed steel to structural steel members, unless indicated otherwise.
2. Install in accordance with manufacturer's written instructions and with special installation tool.

C. Welded Connections:

1. Welding shall not be used for material thinner than 0.0451-inch.
2. Weld framing members and accessories in accordance with AWS D1.3.
3. Resistance welding for prefabricated framing shall be in accordance with AWS C1.1 and AWS C1.3.
4. Repair galvanized surfaces damaged by welding with zinc-rich spray paint in accordance with ASTM A780.

D. Concrete Anchors: Install in accordance with Section 05500, Metal Fabrications.

3.04 FIELD QUALITY CONTROL

A. An independent testing agency will be retained by Owner to perform following inspections.

1. Welded Connections: Visually inspect in accordance with AWS D1.3, Section 7, and as specified in Section 05050, Welding.
2. Mechanical Fasteners: Visually inspect, in accordance with manufacturer's instructions, for each type of fastener.

B. Repair or replace defective welds and fasteners.

END OF SECTION

SECTION 05500
METAL FABRICATIONS

PART 1 GENERAL

1.01 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.

B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals. Corrosive area includes areas exposed to corrosive atmosphere such as hydrogen sulfide from wastewater.

C. Exterior Area: Location not protected from weather by building or other enclosed structure.

D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.
2. Samples: Color samples of abrasive stair nosings.
3. Watertight Access Door: Anchorage and bracing with detailed design and fabrication drawings sealed by a civil or structural engineer registered in the State of Oregon, as required by Section 01612, Anchorage and Bracing, for loads provided herein.

B. Informational Submittals:

1. Watertight Access Door: Complete assembly and anchorage design calculations sealed by a civil or structural engineer registered in the State of Oregon, as required by Section 01612, Anchorage and Bracing, for loads provided herein. Submit with Action Submittal for the same item.
   a. Include structural stress and deflection analysis of complete structural assembly components and connections.
2. Watertight Access Door: Furnish manufacturer's certification of leak tightness based on actual tests conducted on this door, or a door similar in design, to verify it will withstand specified hydrostatic pressure with no evident leakage.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.
2. Watertight Access Door Designers: Engineer registered in state where building is to be erected.
3. Watertight Access Door Fabricator: Minimum of 5 years' experience.
4. Watertight Access Door Manufacturer:
   a. At least 5 years' experience in work of type required in this section.
   b. Production capacity to provide work required for this Project without delay.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy 6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (Type 316L for welded connections)
Shapes	A276, AISI Type 304 (Type 304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (Type 316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 36, with weldability supplement S1.
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844

Item	ASTM Reference
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grade C-1010 through Grade C-1020
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on the Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

1. Plastic:
   a. Single unit construction with corrugated sleeve.
   b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
   c. Material: High-density polyethylene.
2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

A. See Section 05020, Post-Installed Anchors.

2.04 EMBEDDED STEEL SUPPORT FRAMES FOR FLOOR PLATE AND GRATING

A. Steel angle support frames to be embedded in concrete shall be stainless steel, ASTM A276, AISI Type 316, unless indicated otherwise.

B. Welded anchors for stainless steel support frames shall also be stainless steel.

2.05 ABRASIVE NOSING FOR STAIRS

A. Unless otherwise shown on the Drawings, furnish flush type abrasive nosings on stairs.

B. Nosing Components:

1. Homogeneous epoxy abrasive, with minimum 50 percent aluminum oxide content, formed and cured upon an extruded aluminum base.
2. Epoxy abrasive shall extend over and form curved front edge of nosing.
3. Base of Nosing: Extruded aluminum alloy, 6063-T5, heat-treated.

C. Anchoring System: Double-set anchors consisting of two rows of integrally extruded anchors.

D. Size: 3 inches wide by 1/4-inch to 3/8-inch thick by length as shown.

E. Color: Selected by Engineer from manufacturer’s standard color range.

F. Manufacturers and Products:

1. Wooster Products, Inc., Wooster, OH; Spectra Type WP3J and Spectra Type WP3C.
2. American Safety Tread Co., Inc., Helena, AL; Type BF-311D and Type FA-311D.

2.06 FLOOR PLATE

A. Material:

1. Galvanized Steel: Carbon steel, ASTM A786/A786M, commercial grade, hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
2. Stainless Steel: ASTM A793, AISI Type 304.
3. Aluminum: ASTM B632/B632M, Alloy 6061-T6.

B. Minimum Thickness:

1. Steel: 1/4-inch, unless shown otherwise on the Drawings.
2. Aluminum: 3/8-inch, unless shown otherwise on the Drawings.

C. Surface: Raised-lug pattern or diamond tread, unless shown otherwise on the Drawings.

D. Slip-Resistant Surface:

1. Provide where indicated on the Drawings.
2. Manufacturers and Products:
   a. IKG/Borden, Clark, NJ; MEBAC 2.
   b. W.S. Molnar Co., Detroit, MI; SLIPNOT Grade 2–Medium.

2.07 WATERTIGHT ACCESS DOOR

A. Fabricated Unit: Door and frame assemblies designed for no visible leakage under design hydrostatic pressure.

B. Size: As shown on the Drawings.

C. Design Requirements:

1. Complete assembly, each component and anchorage to building to be designed to withstand hydrostatic pressure of 16 feet of water above top of frame for the two at grade locations and 40 feet of water above top of frame for the bottom of Digester location.
2. Safety Factor: 2; based on yield at 0.2 percent offset.
3. See the Drawings for additional information.

D. Materials:

1. Structural Plates and Shapes: Embedded thimble:
   a. Type 316 stainless steel; Cover plate: Type 304 stainless steel.
2. Gaskets: Molded neoprene with fully molded corners.

E. Frame and Subframe: Continuously welded stainless steel with anchors for embedment in concrete.

F. Door: 1-inch minimum thick stainless steel.

G. Hardware:

1. Bolts: Type 316 stainless steel, 3/4-inch minimum diameter at 12 inches on center spacing.

H. Finishes:

1. Stainless Steel: ASTM A480/A480M, No. 2.

I. Test and Inspections:

1. Test welds in leak path in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Appendix VIII.
2. Certify watertightness of assembly under hydrostatic pressure specified. Basis of certification shall be full-scale factory tests of assembly, or assembly of similar design.

2.08 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

B. Neoprene Gasket:

1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on the Drawings.
2. Thickness: Minimum 1/4-inch.
3. Furnish without skin coat.
4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

2.09 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer's instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09900, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09900, Painting and Coating, unless indicated otherwise.
3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.

5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09900, Painting and Coating, unless indicated otherwise.

G. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for use in contact with sewage. Cover full bearing surfaces.

H. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

I. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.10 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer’s recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.
3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

D. Steel Lintels and Shelf Angles: Provide as required for support of masonry and other construction not attached to structural steel framing, unless otherwise shown on the Drawings.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at time concrete is placed.

B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.

C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 ABRASIVE NOSINGS

A. Provide abrasive nosings on concrete steps not being supplied or coated with another type of nosing or nonskid material.

3.04 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09900, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer’s written instructions.

B. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

C. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

3.05 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09900, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

3.06 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance:

1. In accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings.
2. Contractor responsibilities and related information on special inspection, observation, and testing are included in Section 01451, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control:

1. Inspection and testing required in Section 01450, Quality Control.
2. Manufacturer's Certificate of Compliance per Section 01600, Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01600, Product Requirements and Section 01612, Anchorage and Bracing.

3.07 FASTENER SCHEDULE

A. Unless indicated otherwise on the Drawings, provide fasteners as follows:

Service Use and Location	**Product**	**Remarks**
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09900, Painting and Coating

Service Use and Location	Product	Remarks
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09900, Painting and Coating
3. Post-Installed Anchors: See Section 05020, Post-Installed Anchors		
4. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
5. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
6. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 05516
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

C. Special Inspection: As defined by the ICC IBC.

D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

1.02 DESIGN REQUIREMENTS

A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.

1. Railing System:
   a. Capable of withstanding the following load cases applied:
      1) Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
      2) Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
      3) Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. Toeboard: Capable of withstanding, without failure, force of at least 50 pounds applied in downward or outward direction at any point along toeboard.
3. Calculated lateral deflection at top of posts shall not exceed 1-inch.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Manufacturer's literature and catalog data of railing and components.
   c. Design Data:
      1) Calculations or test data using specified design performance loads and including the following:
         a) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
         b) Design of post base connection.
         c) Documentation that concrete anchors have been designed in accordance with one of the following:
            (1) ACI 318, Chapter 17.
            (2) ICC Evaluation Services Report for selected anchor.

B. Informational Submittals:

1. Manufacturer's assembly and installation instructions.
2. Special Inspection: Manufacturer's instructions for Special Inspection of post-installed anchors.
3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
   a. Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
      1) Railing and post connections.
      2) Railing wall connections.
      3) Railing expansion joint connections.
   b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
   c. Deflection Criteria:
      1) In accordance with ASTM E985 and design loads specified, except as follows:
         a) Maximum calculated lateral deflection at top of posts shall not exceed 1-inch.

d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.

4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

1.04 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to extent possible until railing is completely installed.

B. Delivery:

1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
2. Deliver toeboards loose for field assembly.
3. Deliver clear anodized railing pipe and posts with protective plastic wrap.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and installation of railings to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperature of material as a result of both solar heat gain and night time sky heat loss. Temperature change is difference between high or low temperature and installation temperature.

1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

A. General:

1. Furnish pre-engineered and prefabricated railing systems as shown on the Drawings.
2. Railing systems using pop rivets or glued railing construction are not permitted.
3. Sand cast accessories and components are not permitted.
4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, Alloy 6061-T6, or equivalent.
2. Tensile Strength: 38,000 pounds per square inch, minimum.
3. Yield Strength: 35,000 pounds per square inch, minimum.
4. Nominal Wall Thickness: 0.145-inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
   a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
   b. Gauge metal components are not acceptable for load-resisting components.
   c. Fittings shall match color of pipe in railings.
2. Miscellaneous Extruded Aluminum Parts: Alloy 6063-T6, Alloy 6061-T6, or Alloy 6105 T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
   a. Cast Al-mag with sufficient strength to meet load and test requirements.
   b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.
4. Post Anchorages:
   a. Refer to standard details for types of post anchorages and minimum requirements.
   b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 316 stainless steel bolts or concrete anchors.

6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Toeboards:
   a. Molded or extruded Alloy 6063-T6 or Alloy 6061-T6 aluminum.
   b. Provide slotted holes for expansion and contraction where required.

D. Finishes:

1. Railings at Digester lower concrete stairwell, Architectural Class 1 per AA:
   a. AA-M12C22A42 medium bronze anodized.
2. Railings at Digester roof and walkway, meeting requirements of AAMA 605.2:
   a. Fluoropolymer coating: “KYNAR” based coating for minimum 70 percent “KYNAR” resin content.
   b. Color: Green, to match existing Digesters.
3. Other railings: In accordance with AA DA F45, Designation AA-M32-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 316.
2. Post-installed anchors in accordance with Section 05020, Post-Installed Anchors, unless otherwise specified herein.
3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
   a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
   b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

C. Shop Assembly:

1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
2. Fit dowels tightly inside posts.

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Field fabrication of aluminum railing systems is not permitted.

B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

D. Modification to supporting structure is not permitted where railing is to be attached.

E. Protection from Entrapped Water:

1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.

2. For posts mounted in concrete, bends, and elbows occurring at low points, drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.

B. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

C. Posts and Rails:

1. Surface Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Set posts plumb and aligned to within 1/8-inch in 12 feet.
3. Set rails horizontal or parallel to slope of steps to within 1/8-inch in 12 feet.
4. Install posts and rails in same plane.
5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets: Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.

3. Dimension between bottom of toeboard and walking surface not to exceed 1/4-inch.
4. Install plumb and aligned to within 1/8-inch in 12 feet.
5. Attach toeboards to posts via clamp that complies with design requirements while facilitating expansion and contraction. Do not screw directly to post or base.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09900, Painting and Coating.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01451, Special Inspection, Observation, and Testing.

C. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01450, Quality Control.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

C. If stain remains after washing, restore in accordance with railing manufacturer’s recommendations or replace stained railings.

END OF SECTION

SECTION 05530
METAL GRATINGS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
   c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
   d. Manufacturer’s specifications, including coatings, surface treatment, and finishes.

B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

1.02 DELIVERY, STORAGE, AND HANDLING

A. As far is practical, factory assemble items.

B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. IKG, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.

2.02 GRATING MATERIALS

A. Aluminum: Provide alloy and temper as designated below.

1. Bearing Bars and Banding: ASTM B221 Alloy 6061-T6 or Alloy 6063-T6.
2. Swaged Crossbar Rods: ASTM B221 Alloy 6061 or Alloy 6063, or ASTM B210/B210M Alloy 3003.
3. Finish: Mill.

2.03 LIGHT-DUTY AND MEDIUM-DUTY METAL BAR GRATING (TYPE A AND TYPE B)

A. General Requirements:

1. Maximum Service Load:
   a. Light Duty (Type A): 100 psf uniformly distributed load.
   b. Medium Duty (Type B): 500 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4-inch, whichever is less.
3. Bearing Bar Spacing:
   a. Light Duty: 1-3/16-inch maximum, center-to-center.
   b. Medium Duty: 15/16-inch maximum, center-to-center.
4. Cross Bar Spacing: 4 inches maximum, center-to-center. For aluminum I-bar grating with depths greater than 2 inches, provide cross bars at 2 inches maximum, center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on the Drawings.

B. Grating Materials: Aluminum, pressure-locked I-bar grating fabricated by swaging crossbars between extruded I-shaped bearing bars.

C. Surface: Split-Resistance surface, factory applied onto a metal substrate by metalizing.

1. Slipnot Grade 2-medium.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 ACCESSORIES

A. Embedded Frames: As indicated on the Drawings and as specified in Section 05500, Metal Fabrications.

B. Grating Clamps:

1. Use at flanged beam and bolted angle frame supports.
2. Removable from above grating walkway surface.
3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
4. Manufacturers and Products:
    a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
    b. Grating Fasteners, Inc., Harvey, LA; G-Clip.

C. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.
4. Manufacturers and Products:
    a. Welded Stud Anchor:
        1) Nelson Stud Welding, Inc., Elyria, OH.
        2) Stud Welding Associates, Inc. Elyria, OH.
    b. Saddle Clip:
        1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
        2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
        3) Struct-Fast, Inc., Baltimore, MD; Grate-Fast.
5. At Embedded Extruded Aluminum:
    a. Provide aluminum clip, bolt, nut, and washer, with clip engaging bottom flange of I-bar.
    b. Manufacturers and Products:
        1) Direct Metals Company, LLC, Kennesaw, GA; Plank Clip.
        2) Thompson Fabricating Company, Inc., Birmingham, AL; TFCO Standard Hold Down Clip.

2.05 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.

4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Cutouts:
   a. Fabricate in grating sections for penetrations indicated.
   b. Arrange to permit grating removal without disturbing items penetrating grating.
   c. Edge band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
6. Do not notch bearing bars at supports to maintain elevation.
7. Field measure areas to receive grating. Verify dimensions of new fabricated supports and fabricate to dimension required for specified clearances.
8. Section Length: Sufficient to prevent section from falling through clear opening when oriented in the span direction and one end is touching either the concrete or the vertical leg of grating support.
9. Minimum Bearing: 1 inch for grating depth up to 2-1/4 inches and 2 inches for grating depth greater than 2-1/4 inches.
10. Banding and Toe Plates: Same material as grating and welded to bearing bars in accordance with requirements of NAAMM MBG 531 and NAAMM MBG 532.

B. Light-Duty and Medium-Duty Metal Bar Grating: Single grating section shall be not less than 1.5 feet or greater than 3 feet in width or weigh more than 150 pounds.

C. Supports:

1. Same material as grating, except that supports which are to be embedded in concrete shall be Type 316 stainless steel, unless part of an extruded aluminum system.
2. Coordinate dimensions and fabrication with grating to be supported.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09900, Painting and Coating.
2. Allow paint to dry before installation of material.

3.02 INSTALLATION

A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in area of potential fall hazard.

B. Install manufactured products in accordance with manufacturer's recommendations.

C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.

D. Install grating supports plumb and level as applicable.

E. Install sections of welded frames with anchors to straight plane without offsets.

F. Field locate and install fasteners to fit grating layout.

G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.

H. Each grating or plank section shall be easily removable and replaceable.

I. Completed installation shall be rigid and neat in appearance.

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09900, Painting and Coating.

END OF SECTION

SECTION 07190
WATER REPELLENTS

PART 1 GENERAL

1.01 REFERENCES

A. Environmental Protection Agency (EPA): Method 24, Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data for water repellent including description, limitations to coating, chemical properties and percentage of solids.

B. Informational Submittals:

1. Manufacturer's current application instructions for water repellent.
2. Evidence of applicator certification by product manufacturer.
3. Test Reports: Certified test reports showing compliance with specified performance characteristics and physical properties.

1.03 QUALITY ASSURANCE

A. Qualifications: Applicator certified by product manufacturer.

B. Mockup:

1. Apply water repellent following manufacturer's application instructions to not less than 16 square feet of substrate material that matches actual job conditions. Determine the optimum coverage rate required for application. Perform mockup on masonry veneer mockup required by specification Section 04813, Masonry Veneer.
2. After sample treatment has cured (approximately 12 hours to 24 hours), water test to verify that substrate is coated with sufficient water repellent to effectively repel moisture from the surface.
3. Verify that application of water repellent materials will produce no surface stains or discoloration, and obtain Engineer's acceptance.
4. Maintenance: Maintain mockup during construction for workmanship comparison; remove and legally dispose of mockup when no longer required.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials in manufacturer's original sealed containers.

B. Storage and Protection: Store materials protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer.

1. Lids must be kept tightly sealed. Do not allow moisture to enter containers.
2. Store containers in a dry place, upright and airtight at temperatures of 45 degrees F (7 degrees C) and not exceeding 100 degrees F (38 degrees C).

1.05 PROJECT CONDITIONS

A. Surface, air, and material temperatures shall not be lower than 40 degrees F or higher than 95 degrees F during application unless otherwise permitted by manufacturer's instructions. Do not apply when temperature is expected to fall below 40 degrees F within 12 hours following application.

B. Weather: Clear with no precipitation during application or expected for 4 hours following application.

C. Provide positive ventilation throughout the application.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Applied Water Repellent: Material to restrict moisture absorption in material being treated, as recommended by manufacturer for a specific substrate.

B. Characteristics:

1. UV resistant.
2. Single component.
3. Water based.
4. Minimum Active Siloxane/Silane Content: By weight, 7 percent minimum.
5. Will not alter appearance of masonry or change the surface texture.
6. VOC content less than 100 grams per liter using EPA Method 24.
7. No fillers, stearates, or paraffin.
8. Clear color.

9. Ultra-low viscosity.
10. Breathable.

2.02 MANUFACTURERS AND PRODUCTS:

A. Evonik Industries; Protectosil, AQUA-TRETE EM.

B. Tnemec Co., Inc.; Chemprobe Coating Systems, Prime-A-Pell H2O.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Verify that surfaces are solid, dry, and free of dirt, efflorescence, oil, wax, frozen matter, loose particles, cracks, pits, laitance, curing compounds, and other foreign matter that would block absorption of water repellent.

B. Verify that curing of sealants is complete.

C. Clean masonry and concrete surfaces to make them acceptable for application.

D. Protect and mask adjacent surfaces during application.

3.02 APPLICATION

A. Follow product manufacturer's instructions and recommendations, including application apparatus and techniques, and coverage rates.

B. Provide uniform coverage over entire surface of exposed concrete masonry (sound/screen wall), concrete masonry veneer and vertical concrete surfaces of Digester 3 as indicated on the Drawings. Apply prior to installation of sheet metal conductor heads and downspouts.

3.03 FIELD QUALITY CONTROL

A. Notify Engineer 48 hours prior to application.

B. ~~After water repellent has dried (24 hours, low humidity, medium temperature (70 degrees F to 90 degrees F) and 48 hours, high humidity, low temperature (50 degrees F to 69 degrees F), test surfaces with a water spray. Recoat areas that indicate water absorption.~~Provide uniform coverage over the entire surface of exposed concrete masonry (sound/screen wall), concrete masonry veneer, and vertical and horizontal concrete surfaces of Digester 3 as indicated on the Drawings. Apply prior to installation of sheet metal conductor heads and downspouts.[ADD. 6]

3.04 CLEANING

A. At completion, remove from the Job Site excess material, debris, and waste. Dispose of water repellent containers according to state and local environmental regulations.

B. Upon completion of Work, clean window glass and other splattered surfaces.

3.05 PROTECTION

A. Protect adjacent shrubs, metal, wood trim, glass, asphalt, and other building hardware from overspray. Do not permit spray mist or liquid to drift onto surrounding properties or parking lots. Avoid contact with automobile paint and windshields. Clean up immediately after application using cleaners approved by product manufacturer.

B. Protect installed product's finish surfaces from damage during construction.

END OF SECTION

SECTION 07210
THERMAL INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C1289, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
   b. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer’s product literature identifying products proposed for use.

1.03 DELIVERY, STORAGE, AND HANDLING

A. On packaging clearly identify manufacturer, contents, brand name, applicable standard, and R-value.

B. Store materials off ground and keep them dry. Protect against weather, condensation, and damage.

PART 2 PRODUCTS

2.01 RIGID INSULATION

A. Polyisocyanurate:

1. ASTM C1289, Type 1.
2. Flame Spread: Less than 25 when tested in accordance with ASTM E84.
3. Compressive Strength (ASTM C1289): 25 pounds per square inch minimum.
4. R-6 Minimum per Inch Thickness.
5. Manufacturers and Products:
   a. Rmax; Thermasheath.
   b. Atlas: EnergyShield.
   c. GAF; EnergyGuard.
   d. Johns Manville; AP Foil-Faced.

PART 3 EXECUTION

3.01 RIGID INSULATION

A. Install in accordance with the following:

1. Install boards in location and in thickness as shown.
2. Cut insulation with saw, knife, or other sharp tool to fit tightly around obstructions.
3. Butt insulation boards together tightly at joints.
4. Where thickness required exceeds 1-1/2 inches, install two layers of boards.
5. Apply to concrete with adhesive recommended by insulation manufacturer:
   a. Adhere first layer to substratum, then adhere second layer to first, staggering joints.
   b. Follow manufacturer's recommendations for preparing surfaces and applying adhesive.

END OF SECTION

SECTION 07620
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
   b. B32, Standard Specification for Solder Metal.
   c. C1311, Standard Specification for Solvent Release Sealants.
2. FM Global (FM):
   a. Loss Prevention Data Sheet 1-49, Perimeter Flashing.
   b. DS 1-29, Roof Deck Securement and Above-Deck Roofing Components.
3. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 1013, Architectural Sheet Metal Manual.

1.02 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Thermal Movements:

1. Provide sheet metal flashing and trim that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures for preventing buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects.
   a. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.
2. Provide clips that resist rotation and avoid shear stress as a result of sheet metal and trim thermal movements.
3. Base engineering calculation on surface temperatures of materials as a result of both solar heat gain and nighttime-sky heat loss.

C. Water Infiltration: Provide sheet metal flashing and trim that does not allow water infiltration to building interior.

1.03 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA 1013. Conform to dimensions and profiles shown, unless more stringent requirements are indicated.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Show joints, types and location of fasteners, and special shapes.
   b. Catalog data for stock manufactured items.
2. Samples:
   a. Selection: Manufacturer's full range of colors for items to be factory finished.
   b. Verification: Physical samples of initially selected color for confirmation of color selection.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Inspect for damage, dampness, and wet storage stains upon delivery to Site.

B. Remove and replace damaged or permanently stained materials that cannot be restored to like-new condition.

C. Carefully handle to avoid damage to surfaces, edges, and ends.

D. Do not open packages until ready for use.

E. Store materials in dry, weathertight, ventilated areas until immediately before installation.

PART 2 PRODUCTS

2.01 METAL

A. Prefinished Galvanized Steel Sheet: ASTM A924/A924M, Grade A or ASTM A653/A653M, G90 zinc coating; 24-gauge (0.02-inch) core steel, shop prefinished with fluoropolymer coating (Kynar polyvinylidene fluoride resin) coating; color as selected from manufacturer's standard color range.

2.02 REGLETS AND COUNTERFLASHING

A. For Concrete:

1. Stainless steel, 0.015 inch.
2. Manufacturers and Products:
   a. Fry Reglet Corp.; Fry Springlok Type CO and Springlok Flashing.
   b. Cheney Flashing Co.; Type A reglet and Snap Lock Cap Flashing.

B. For Masonry:

1. Stainless steel, 0.015-inch.
2. Manufacturers and Products:
   a. Fry Reglet Corp.; Fry Springlok Type MA and Springlok Flashing.
   b. Cheney Flashing Co.; Type B reglet and Snap Lock Cap Flashing.

2.03 DOWNSPOUTS, SCUPPERS, AND CONDUCTOR HEADS

A. Use specified prefinished galvanized sheet metal.

2.04 ANCILLARY MATERIALS

A. Solder: ASTM B32, alloy composition Sn 60 for stainless steel.

B. Soldering Flux: ASTM B32, Type RA.

C. Sealing Tape: Polyisobutylene sealing tape.

D. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil thick minimum polyester.

E. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

F. Fasteners:

1. Stainless Steelwork: Stainless steel.

2.05 COPINGS

A. ~~Prefabricated~~ Coping System:[ADD. 6]

1. Snap-on system, stucco embossed pattern aluminum, 0.050-inch minimum thickness.

2. Include ancillary items, such as mitered and welded corners, and end caps, where shown and as required for complete system.
3. Configuration:
   a. Curved to match wall.
   b. Tapered with 4-inch minimum face edges.
4. Manufacturers and Products:
   a. Johns Manville; PrestoLock FA.
   b. Firestone Building Products Co.; Coping.
   c. Dow Roofing Systems; Tapered Coping.
   d. Carlisle SynTec; Secure Edge 300 Parapet Wall Coping.

B. Finish: Factory finished with full strength fluoropolymer coating (Kynar 500 polyvinylidene fluoride resin) in color as selected.

2.06 FABRICATION OF FLASHING

A. Field measure prior to fabrication.

B. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.

C. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

D. Seams:

1. Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

E. Reinforcements and Supports: Provide same material as flashing, unless other material is shown. Steel, where shown or required, shall be galvanized or stainless.

F. Rigid Joints and Seams: Make mechanically strong. Solder stainless steel metal joints. Do not use solder to transmit stress.

G. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

H. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

I. Fabricate sheet metal in 10-foot maximum lengths, unless otherwise indicated.

J. Provide watertight closures at exposed ends of counterflashing.

K. Fabricate corners in one-piece with legs extending 30 inches each way to field joint. Lap, rivet, or solder corner seams watertight. Apply sealant if necessary.

L. Neutralize soldering flux.

M. Solvent clean sheet metal. Surfaces to be in contact with roofing or otherwise concealed shall be coated with isolation paint.

N. Pipe Penetrations through Roof: As shown on the Drawings.

O. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

P. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

1. Thickness: As recommended by SMACNA 1013 and FM Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

2.07 FABRICATION OF DOWNSPOUTS, SCUPPERS, AND CONDUCTOR HEADS

A. Form downspouts and gutters in maximum lengths as practicable to sizes and shapes indicated on the Drawings:

1. Telescope end joints 1-1/2 inches and lock longitudinal joints of downspouts.
2. Provide elbows at bottom where downspouts empty onto splash blocks.

B. Form scuppers and conductor heads to shapes and sizes indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flashing:

1. General:
   a. Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA 1013.
   b. Provide concealed fasteners where possible, set units true to line, and level as indicated.
   c. Install work with laps, joints, and seams that will be permanently watertight.
2. Isolate metal from wood and concrete and from dissimilar metal with isolation tape or two coats of isolation paint.
3. Use only stainless steel fasteners to connect isolated dissimilar metals.
4. Joints: 10-foot maximum spacing and 2-1/2 feet from corners, butted with 3/16-inch space centered over matching 8-inch long backing plate with sealing tape in laps.
5. Set flanges of flashings and roof accessories on continuous sealing tape.
6. Joints, Fastenings, Reinforcements, and Supports: Sized and located as required to preclude distortion or displacement as a result of thermal expansion and contraction.
7. Conceal fastenings wherever possible.
8. Set flashing and sheet metal to straight, true lines with exposed faces aligned in proper plane without bulges or waves.

B. Prefabricated Metal Systems:

1. Follow system manufacturer’s printed instructions.
2. Place color variations in pieces so no extremes are next to each other.

C. Downspouts, Scuppers, and Conductor Heads: Anchor downspouts to wall with straps of same material as downspouts. Install scuppers, and conductor heads as indicated on the Drawings.

D. Prefabricated Metal Coping: Provide at Digester 3 sound wall in accordance with applicable recommendations of FM DS 1-49 and manufacturer’s installation recommendations.

3.02 FINISH

A. Exposed Surfaces of Flashing and Sheet Metalwork: Free of dents, scratches, abrasions, or other visible defects, and clean and ready for painting where applicable.

3.03 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder and sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07900
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C661, Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer.
   b. C834, Standard Specification for Latex Sealants.
   c. C920, Standard Specification for Elastomeric Joint Sealants.
   d. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data: Supplier’s product data for each specified item.
2. Shop Drawings: Surface preparation instructions. Indicate where each product is proposed to be used.
3. Samples: Material proposed for use showing color. As selected from manufactures standard range of colors .

B. Informational Submittals:

1. Installation instructions.
2. Documentation showing applicator qualifications.
3. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum of 5 years’ experience installing sealants in projects of similar scope.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

1.05 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Provide special guarantee for correction or, at the option of the Owner, removal and replacement of Work specified in this section found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work is specified in the General Conditions.

B. Conditions: No adhesive or cohesive failure of sealant.

C. Sealed Joints: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

A. Characteristics:

1. Uniform, homogeneous.
2. Free from lumps, skins, and coarse particles when mixed.
3. Nonstaining, nonbleeding.
4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
5. Immersible may be substituted for nonimmersible provided all other specified requirements are met.

B. Color: Unless specifically noted, match color of the principal material adjoining area of application. Final color to match approved Samples or as selected by Engineer.

C. Type 1—Silicone, Nonsag, Nonimmersible:

1. Silicone base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of withstanding movement up to 50 percent of joint width.
3. Manufacturers and Products:
   a. Dow Chemical Co.; DOWSIL 790.
   b. General Electric; SCS2000 Silpruf.
   c. Sika Corp.; Sikasil N Plus US.

D. Type 2—Multipart Polyurethane, Self-leveling, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora Corp.; Dynatrol II-SL.
   b. Sika Corp.; Sikaflex-2c SL.

E. Type 3—Multipart Polyurethane, Nonsag, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora; Dynatrol II.
   b. Sika Corp.; Sikaflex-2c NS EZ Mix.

F. Type 4—Multipart Polyurethane, Nonsag, Nonimmersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Manufacturers and Products:
   a. Pecora Corp.; Dynatrol II.
   b. Sika Corp.; Sikaflex-2c NS EZ Mix.

G. Type 5—One-part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. Tremco; Vulkem 45SSL.
   b. Sika Corp.; Sikaflex-1c SL.

H. Type 6—One-part Polyurethane, Nonimmersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Manufacturers and Products:
   a. Tremco; Dymonic 100.
   b. Sika Corp.; Sikaflex-1a.

I. Type 7—Multipart Polysulfide, Immersible:

1. Polysulfide base, two-component, chemical curing; ASTM C920, Type M, Grade P or Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. For use above grade and below grade.
4. Manufacturers and Products:
   a. W. R. Meadows; Deck-O-Seal Gun Grade, two-part.
   b. Pecora Corp.; Synthacalk GC2+.

J. Type 11—Fire Penetration Seal:

1. Manufacturers and Products:
   a. 3M Corp.; Fire Barrier Sealant CP 25WB+ and Fire Barrier Moldable Putty Stix MP+.
   b. Specified Technologies Inc.; SpecSeal LCI Intumescent Sealant.
   c. Hilti USA; CP 604.

K. Type 12—One-part Polycarbonate, Immersible:

1. Polycarbonate base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturer and Product: Pro-Seal Products, Inc.; Pro-Seal 34.

L. Type 13—Tape Sealant:

1. Compressible polyurethane foam impregnated with polybutylene or polymer-modified asphalt.
2. Color: Black.
3. Size: 3/4-inch wide by length required by expanded thickness recommended by manufacturer for particular application.
4. Manufacturer and Product: Sika Corp., Emseal Joint Systems, Ltd.; AST Hi-Acrylic.

2.02 BACKUP MATERIAL

A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16-inch wide.

C. Manufacturers and Products:

1. BASF; MasterSeal 920 and 921 (Closed-cell Backing Rod).
2. Pecora Corporation; Green Rod.
3. Tremco; Closed-cell Backing Rod.
4. W.R. Meadows; Cera-Rod and Kool-Rod.

2.03 ANCILLARY MATERIALS

A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 GENERAL

A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.

B. Install joint sealants in accordance with ASTM C1193.

C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.

D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

E. Use joint sealant as required for the applicable application and as follows:

Joint Size	Sealant Type
Less than 1"	1, 2, 3, 4, 5, 6, 7, 10, or 12
Less than 2"	1, 2, 3, 4, or 7
Over 2"	Follow manufacturer’s recommendation

3.02 PREPARATION

A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.

B. Sealed surfaces to be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.

1. Mask adjacent surfaces where necessary to maintain neat edge.
2. Starting of work will be construed as acceptance of subsurfaces.
3. Apply primer to dry surfaces as recommended by sealant manufacturer.

C. Verify joint shaping materials and release tapes are compatible with sealant.

D. Examine joint dimensions and size materials to achieve required width or depth ratios.

E. Follow manufacturer's instructions for mixing multi-component products.

3.03 INSTALLATION

A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.

1. Install backup material as recommended by sealant manufacturer.
2. Where possible, provide full length sections without splices; minimize number of splices.
3. Tape sealant may be used as joint filler if approved by sealant manufacturer.

B. Use bond breaker where recommended by sealant manufacturer.

C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.

D. Joint Sealant Materials: Follow manufacturer's recommendation and instructions, filling joint completely from back to top, without voids.

E. Joints: Tool slightly concave after sealant is installed.

1. When tooling white or light color sealant, use a water wet tool.
2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

F. Tape Sealant: Compress to 50 percent of expanded thickness and install in accordance with manufacturer's instructions.

3.04 CLEANING

A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.

B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

3.05 JOINT SEALANT SCHEDULE

A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Concrete Walls (except water-holding and belowgrade portions of structures)	1, 3, 4, 5, 6, 12
Concrete Floor Slabs (except for water-holding Structures)	2, 5
Concrete Walls and Slabs immersed in water and/or below grade	7
Slabs Subject to Vehicle and Pedestrian Traffic	2, 5
Masonry Walls	1, 5, 6
Material Joints At:	
Metal Door, Window, and Louver Frames (Exterior)	1, 5, 6
Metal Door, Window, and Louver Frames (Interior)	1, 5, 6
Wall Penetrations (Exterior)	1, 5, 6, 12
Wall Penetrations (Interior)	1, 5, 6
Floor Penetrations	5, 6, 7
Ceiling Penetrations	1, 3, 4, 5, 6, 7
Roof Penetrations	5
Sheet Metal Flashings	5, 13
Sheet Metal Siding	5, 13

Joint Locations	Sealant Type(s)
Other Joints:	
Threshold Sealant Bed	5
Openings Around Pipes, Conduits, and Ducts Through Fire-Rated Construction	11

END OF SECTION

SECTION 09500
ACOUSTIC TREATMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
   b. ASTM E90: Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
   c. ASTM C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Elevation drawings for each wall indicated to receive acoustic treatment showing proposed locations.
   b. Profile, gauge, and location of panels.
   c. Location and type of fasteners and subgirts.
   d. Location, gauge, shape, and method of attachment of all trim.
   e. Sample: Submit, at minimum, a 4-inch by 4-inch sample for each type of specified acoustical panel.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers: Provide acoustical wall panels from a single manufacturer.
2. Installers: Utilize an installer having demonstrated experience on projects of comparable size and complexity.

B. Performance Requirements:

1. Surface Burning Characteristics: Acoustical panels to perform as specified when tested in accordance with ASTM E84. Acoustical panel surface burning performance should comply with the International Building Code and other local building code requirements.
2. Acoustical Characteristics: Acoustical panels to perform as specified when tested in accordance with ASTM C423, and ASTM E90.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Upon delivery to Site, inspect materials for damage, dampness, and wet storage stains.
2. Do not uncrate materials until ready for use.
3. Handle panels carefully to avoid any damage.

B. Storage:

1. Store panels indoors in a clean, cool, dry place, and out of direct sunlight.
2. Store panels on edge, positioned to allow moisture to run off rather than accumulate on the faces.
3. Separate so air can circulate around every surface.
4. Protect products from weather, abuse, defacement, and damage.

PART 2 PRODUCTS

2.01 SOUND-ABSORBENT PANEL SYSTEM

A. Acoustic Wall Panels:

1. Panel Composition: Semi-rigid porous expanded polypropylene acoustical bead foam; rated for outdoor use.
2. Panel Thickness: 2 inches.
3. Panel Size: 2 feet by 4 feet.
4. Edge Profile: Beveled.
5. Finish: Charcoal Grey.
6. Mounting Method: Direct Attachment or Z-Bars.

B. Product Performance:

1. Acoustical Performance:
   a. Noise Reduction Coefficient (NRC) per ASTM C423.
   b. Thickness: 2 inches.
   c. A Mount: 0.70.
2. Sound Transmission Classification (STC) per ASTM E90:
   a. Thickness: 2 inches.
   b. STC: 13.
   c. OITC: 11.
3. Surface Burning Performance:
   a. Fire Rating per ASTM E84: Class A.

C. Manufacturer and Products:

1. Acoustical Surfaces, Inc.; Sound Silencer (Basis of Design).
2. “Or-equal.”

2.02 ACCESSORIES

A. Attachment hardware for wall panels as specified by manufacturer for installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:

1. Examine surfaces scheduled to received furred out acoustical units for unevenness, irregularities or dampness that would affect quality and execution of work.
2. All wet work in the installation area must be complete, cured, and dry prior to installation.
3. Wall assembly shall be complete, inspected, and accepted before wall work begins.

3.02 INSTALLATION

A. Comply with manufacturer’s instructions and recommendations for installation of wall panels and with industry standards.

3.03 CLEANING

A. Clean surfaces of wall panels per manufacturer's instructions or recommendations.

END OF SECTION

SECTION 09900
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C209, Tape Coatings for Steel Water Pipe and Fittings.
   b. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   c. C214, Tape Coatings for Steel Water Pipe.
   d. C216, Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel water Pipe and Fittings.
   e. C217, Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE):
   a. SP 0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
   b. SP 0198, Control of Corrosion under Thermal Insulation and Fireproofing Materials–A Systems Approach.
4. Occupational Safety and Health Act (OSHA).
5. The Society for Protective Coatings (SSPC):
   a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
   c. SP 1, Solvent Cleaning.
   d. SP 2, Hand Tool Cleaning.
   e. SP 3, Power Tool Cleaning.
   f. SP 5, White Metal Blast Cleaning.
   g. SP 6, Commercial Blast Cleaning.
   h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
   i. SP 10, Near-White Blast Cleaning.
   j. SP 11, Power Tool Cleaning to Bare Metal.
   k. SP 13, Surface Preparation of Concrete.
   l. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PPDS: Paint Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Samples: For each material to be painted, contractor to provide an 8-inch by 10-inch color draw down sample for final approval.
2. Shop Drawings:
   a. Data Sheets:
      1) For each product, furnish a Paint Product Data Sheet (PPDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PPDS form is appended to the end of this section.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer's literature is not acceptable.
   b. Detailed chemical and gradation analysis for each proposed abrasive material.
3. Applicator's Qualifications: List of references substantiating experience.
4. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.

5. Manufacturer's written verification that submitted material is suitable for the intended use.
6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
7. Manufacturer's written instructions and special details for applying each type of paint.

B. Informational Submittals: Coating manufacturer's Certificate of Compliance, in accordance with Section 01640, Manufacturers' Services and Training.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

1.05 REGULATORY REQUIREMENTS

A. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.

1.06 SURFACE PREPARATION AND COATING APPLICATION

A. Perform surface preparation and painting in accordance with recommendations of the following:

1. These specifications.
2. Paint manufacturer's instructions.
3. SSPC PA 10.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.

2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.

B. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

C. Methods must be used to control dust generation from abrasive blasting operations.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. Akzo Nobel (International; Devoe).
2. Carboline.
3. PPG.
4. Sherwin-Williams.
5. Tnemec.

2.02 ABRASIVE MATERIALS

A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.03 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.

2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition
Acrylic Latex (Semigloss)	Single-component, semigloss finish.
Amine-Cured Epoxy	Amine or phenolic epoxy, minimum 90 percent volume solids.
Block Filler	Primer-sealer designed for rough concrete surfaces, 100 percent acrylic emulsion.
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments.
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated.
Fusion Bonded Coating 100% Solids Epoxy	100 percent solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service.
TFE Lube or Grease Lube	Tetrafluoroethylene, liquid coating, or open gear grease as supplied by McMaster-Carr Supply Corporation, Elmhurst, IL.
High Build Epoxy	Polyamidoamine epoxy, minimum 69 percent volume solids, capability of 4 MDFT to 8 MDFT per coat.
Wax Tape System	In accordance with AWWA C217, with outerwrap
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish.
Tape Coating System	AWWA C214 and C209, with double outer wrap.
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required.

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer and finish coats shall be performed by pipe manufacturer.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
2. Steel Pipe:
   a. Surface preparation and application of primer and finish coats shall be performed by pipe manufacturer.
   b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switch plates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer’s recommendations, the more stringent shall apply.

B. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
    a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
    b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
    c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
    d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.

e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.

g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

i. SP 16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning,” “hand tool cleaning,” “wire brushing,” and “blast cleaning,” or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.

6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
    a. Prepare such that there is:
        1) No undercutting or reverse ridges on weld bead.
        2) No weld spatter on or adjacent to weld or any area to be painted.
        3) No sharp peaks or ridges along weld bead.
    b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
    a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
    b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
    c. Clean small, isolated areas as above or solvent clean with suitable solvent and clean cloth.
9. Blast Cleaning Requirements:
    a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
    b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
    c. Use only dry blast cleaning methods.
    d. Do not reuse abrasive, except for designed recyclable systems.
    e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
10. Post-Blast Cleaning and Other Cleaning Requirements:
    a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
    b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

C. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
2. Brush blast in accordance with SSPC SP 16.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

D. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

E. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

F. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.

7. Application of Cosmetic Coat:
    a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
    b. Check compatibility by application to a small area prior to starting painting.
    c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these specifications is for existing and new, interior and exterior wood, masonry, concrete, metal, and submerged metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Do not paint exterior concrete surfaces, unless specifically indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these specifications and paint manufacturers' printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
6. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
7. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
8. On pipelines, terminate coatings along pipe runs to 1-inch inside pipe penetrations.
9. Keep paint materials sealed when not in use.
10. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such as Concrete and Masonry:

1. Filler or Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
   a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
   a. Minimum required without regard to coating thickness.
   b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
   a. Do not exceed coating manufacturer's recommendations.
   b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
   a. Perform with properly calibrated instruments.
   b. Recoat and repair as necessary for compliance with specification.
   c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Metal surfaces below a plane 1-foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel.

C. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Metal Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces located inside or outside of structures.
   b. Exposed metal surfaces associated with mechanical equipment including, but not limited to, pipe, pumps, valves, fittings, and other appurtenances, and structural components associated with equipment.

D. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Metal Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces when shown or specified.
   b. Exposed metal surfaces not specified to be coated elsewhere.

E. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Use on concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles.

F. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
Steel Pipe and Joints: SP 10, Near-White Metal Blast Cleaning	Tape Coating System	AWWA C214 and C209 with Double Outer Wrap
Ferrous Metal Pipe Fittings, Unless Otherwise Coated as Specified: SP 1, Solvent Cleaning	Wax Tape System	AWWA C217 with Outer Wrap
Other: SP 10, Near-White Metal Blast Cleaning	High Build Epoxy	2 coats, 16 MDFT
Ductile Iron Pipe: NAPF 500-03	Manufacturer's Asphaltic Coating and V-Bio Polyethylene Encasement	In accordance with Section 15200, Process Piping—General

1. Use on the following items or areas:
   a. Buried, belowgrade portions of ferrous metal components, except buried stainless steel and ductile iron pipe.
      1) For steel pipe, tape wrap per AWWA C214 with double outer wrap.
      2) For steel joints, tape wrap per AWWA C209 with double outer wrap, or heat shrink sleeves per AWWA C216 and Section 15200, Process Piping—General.
      3) Buried fittings with irregular shapes, such as flanges, nuts, bolts, thrust ties, couplings, etc., shall receive wax tape system per AWWA 217 with outer wrap.
      4) Other buried components may be coated with high build epoxy.

G. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
   a. Galvanized surfaces requiring painting.
   b. After application of System No. 10, apply finish coats as required for exposure.

H. System No. 14 High Heat-Resistant—700 Degrees F Maximum:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Inorganic Zinc Primer	1 coat, 2.5 MDFT
	Silicone	1 coat, 2 MDFT

1. Use on the following items or areas: Waste Gas Burner 1.

I. System No. 19a Concrete Exposed Metal Repair Coating—Wastewater:

Surface Prep.	Paint Material	Min. Coats, Cover
Concrete: In accordance with Paragraph Concrete Surface Preparation Reinforcing Steel: SP 10, Near-White Metal Blast Cleaning See Note 1	Amine-cured epoxy, suitable for exposure to primary wastewater, finish color gray.	2 coats, 8 MDFTPC, see Note 2.

Surface Prep.	Paint Material	Min. Coats, Cover
Note 1: Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SP 11, Power Tool Cleaning. Note 2: Brush out surface voids and irregularities to provide a monolithic film.		

1. On saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum two inches around ends of exposed metal and rebar in lieu of entire surface.

J. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex (Semigloss)	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.

K. System No. 27 Aluminum Isolation:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 1, Solvent Cleaning	Prime in accordance with manufacturer's recommendations	
	High Build Epoxy	1 coat, 10 MDFT

1. Use on the following items or areas:
   a. Aluminum surfaces embedded or in contact with concrete.
   b. Aluminum surfaces in contact with dissimilar metals, where physical separation is not possible.

L. System No. 29 Fusion Bonded Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Metal Blast Cleaning	Fusion Bonded Coating 100 percent Solids Epoxy	1 or 2 coats, 7 MDFT

1. For steel pipe and fittings, meet all requirements of AWWA C213.
2. Apply surface preparation and all coats to surfaces prior to installation.
3. For coatings under insulation, such as those applied to Hot Water Supply (HWS) and Hot Water Return (HWR) piping, all products must be rated for wet/dry thermal cycling under insulation with a temperature resistance up to 300 degrees F per NACE SP 0198.
4. Use on the following items:
   a. Metal surfaces as shown or specified.
   b. Stainless steel anchor bolts as shown or specified.
   c. Steel piping under insulation.

M. System No. 29A Fusion Bonded, Steel Dowel Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Metal Blast Cleaning	Fusion Bonded Coating 100 percent Solids Epoxy	1 or 2 coats, 7 MDFT
TFE Lube, Shop Applied; Grease Lube Alternative, Field Applied Just Prior to Installation	TFE Lube or Grease Lube	1 coat, as required

1. Use on steel expansion joint dowels as specified in Section 03251, Concrete Joints and Accessories.

3.08 COLORS

A. Provide as designated herein and as selected by Owner.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected.

3. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.
   c. Radiation Hazards: OSHA Purple.
   d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: In accordance with Piping Schedule.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.
4. Pipe Supports: Painted light gray, as approved by Owner.
5. Fiberglass reinforced plastic (FRP) pipe, polyvinylidene fluoride (PVDF), and polyvinyl chloride (PVC) pipe located inside of buildings and enclosed structures will not require painting, except as noted or scheduled.

3.09 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.
2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

B. Testing:

1. Thickness and Continuity Testing:
   a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
   b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
   d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.10 MANUFACTURER'S SERVICES

A. In accordance with Section 01640, Manufacturers' Services and Training, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.11 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.12 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Paint System Data Sheet (PSDS).
2. Paint Product Data Sheet (PPDS).

END OF SECTION

PAINT SYSTEM DATA SHEET (PSDS)

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	**Product Name/Number (Proprietary)**	**Min. Coats, Coverage**

PAINT PRODUCT DATA SHEET (PPDS)

Complete and attach manufacturer's Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning: _____

Ambient Temperature Limitations: min.: _____ max.:_____

Surface Temperature Limitations: min.: _____ max.:_____

Surface Profile Requirements: min.:_____ max.:_____

Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.

PAINT PRODUCT DATA SHEET (PPDS)

Complete and attach manufacturer's Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning: _____

Ambient Temperature Limitations: min.: _____ max.:_____

Surface Temperature Limitations: min.: _____ max.:_____

Surface Profile Requirements: min.:_____ max.:_____

Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.

SECTION 10200
LOUVERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association International, Inc. (AMCA): 500-L, Laboratory Methods of Testing Louvers for Rating.
2. American Architectural Manufacturers Association (AAMA): 2605, Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
3. ASTM International (ASTM):
   a. D822/D822M, Standard Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings.
   b. D1187/D1187M, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   c. D2244, Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates.
   d. D4214, Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films.

1.02 DESIGN REQUIREMENTS

A. Installed Louvers: Capable of resisting wind pressures shown on Components and Cladding Table of Structural Drawings.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Large scale details of louvers, anchorage to structure including proposed fasteners and spacing, and relationship to adjoining construction for each louver condition. Demonstrate compliance with specified performance requirements including scheduled minimum louver free area.
   a. Manufacturer’s Literature: Descriptive and performance data of louvers, including standard drawings.
   b. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Design Criteria on Structural General Notes on the Drawings.

2. Samples:
   a. Manufacturer's standard finishes and colors for initial selection.
   b. Physical color chips using specified metal and paint finish for approval.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Design Criteria on Structural General Notes on the Drawings. Submit with Action Submittal for the same item.
2. Factory test data.
3. Certificates of AMCA ratings.
4. Installation instructions.
5. Special Guarantee.

1.04 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction, or at option of Owner, removal and replacement of special fluoropolymer-based finish found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

1. Conditions:
   a. No peeling, blistering, chipping, cracking, or checking of finish coating.
   b. No chalking, fading, or erosion of finish:
      1) No chalking in excess of 8 numerical ratings in accordance with ASTM D4214.
      2) No change in color or color fade in excess of 5 NBS units in accordance with ASTM D2244 and ASTM D822/D822M.

PART 2 PRODUCTS

2.01 GENERAL

A. Nonacoustical louver sizes are based on percent free area as indicated in the Louver Schedule.

B. Air Performance and Water Penetration: Louvers shall be licensed to bear the AMCA seal under the AMCA Certified Ratings Program.

C. Louvers: Rated and tested in accordance with AMCA 500-L.

D. Furnish louver frame with continuous duct mounting surface where shown on the Drawings.

2.02 FIXED DRAINABLE LOUVER (TYPE DB)

A. Frame: Extruded aluminum channel, 0.081 inch thick, 4 inches deep, interior duct collar, concealed mullions.

B. Blades: Extruded aluminum, minimum 0.081 inch thick, 35-degree to 45-degree pitch angles, with integral front drain gutter, spaced 3 inches to 4 inches on center.

C. Air Performance and Water Penetration: Louvers shall be licensed to bear the AMCA seal under the AMCA Certified Ratings Program.

D. Sizes: As scheduled on the Drawings.

E. Screen: Inside mounted, painted aluminum, 3/4-inch mesh.

F. Finish: Two coats minimum, factory spray applied, baked-on 70 percent Kynar 500 PVDF Fluoropolymer resin-based paint coating; AAMA 2605 in color as scheduled or selected.

G. Manufacturers and Products:

1. Construction Specialties; Model A4097.
2. Ruskin; Model ELF375DX.

2.03 ACCESSORIES

A. Anchors and Fasteners: Type 304 stainless steel.

B. Flashings: Match louver frame.

C. Extended Sills: Formed aluminum, minimum thickness 0.081 inch.

D. Isolation Tape: Tremco 440, 3M EC1202, or Presstite 579.6.

E. Isolation Paint: ASTM D1187/D1187, bituminous coating.

2.04 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. Airflow versus pressure loss.
2. Rain penetration data.

PART 3 EXECUTION

3.01 EXAMINATION

A. Check openings to ensure dimensions conform to the Drawings.

B. Ensure openings are free of irregularities that would interfere with installation.

C. Do not install louvers until defects have been corrected.

3.02 INSTALLATION

A. Install louvers as shown on reviewed Shop Drawings. Coordinate with heating or ventilation ductwork to be connected.

B. Follow procedures in manufacturer's recommended installation instructions.

C. Separate aluminum from other metals with isolation tape or paint.

3.03 CLEANING

A. After erection, protect exposed portions from damage by machines, paint, lime, acid, cement, or other harmful compounds.

B. Remove protective materials and clean with plain water, water with soap, or household detergents.

3.04 SCHEDULE

A. Louver Schedule: A tabulation of louver characteristics for each opening numbered on the General HVAC Drawings. Provide items as scheduled.

END OF SECTION

SECTION 10400
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
2. ASTM International (ASTM):
   a. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   b. D709, Standard Specification for Laminated Thermosetting Materials.
3. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Signage: Drawings showing layouts, materials, actual letter sizes and styles, sign and letter colors, sign finishes, and Project-specific mounting details.
   b. Sign Layout Plan: Submit layout plan for each facility showing locations where scheduled signs are to be placed.
   c. Pipe and Equipment Label Layout Plan: Submit layout plan for each facility showing types, sizes, and locations where pipe and equipment labels are intended to be placed.
2. Samples: One full size for each type of nameplate, sign, and label specified.

B. Informational Submittals: Manufacturer’s installation instructions.

PART 2 PRODUCTS

2.01 IDENTIFICATION LABELS

A. Pipe Labels:

1. Labels: Type as identified in Pipe Label Table.
   a. Printed Full Pipe Wrap: Printed using Graphics Products®, DuraLabel®, “or-equal.”

b. Stencils: Painted on using stencils.
c. Coiled pipe markers that securely snap around the pipe, reusable, and do not required adhesive to affix to pipe, with integral flow arrows, DuraLabel, “or-equal.”

2. Label Size:
   a. Pipe label size as shown in table below to allow easy identification of substance. If pipe is elevated above or blow the normal walking surface the height of the letters should be modified to allow better visibility. Locate labels at intervals that allow for quick and clear identification of substance within the pipe.
   b. Pipe Label Table:

Outside Diameter of Pipe	Minimum Length of Label Field Color (1)	Height of Letters (2)	Max distance between Labels	Type of Label
1/2 inch to 1-1/4 inches	8 inches	1/2 inch	10 feet	Coiled Pipe marker
1-1/2 inches to 2 inches	8 inches	3/4 inch	15 feet	Coiled Pipe marker
2-1/2 inches to 6 inches	12 inches	1-1/4 inches	20 feet	Printed Full Pipe Wrap
8 inches to 10 inches	24 inches	2-1/2 inches	20 feet	Printed Full Pipe Wrap
12 inches to 18 inches	32 inches	4 inches	25 feet	Stencils
> 18 inches	36 inches	6 inches	25 feet	Stencils

      1) Length of pipe label color field will be modified to accommodate the name of the contents in full and any additional descriptors or details.
      2) For situations where pipe is located in difficult to see areas height of letters should be modified to provide better visibility.

3. Letter and Arrow Colors: As indicated in the Piping Schedule located on the Drawings.

4. Color Field: ASME A13.1, Pipe colors as shown in Piping Schedule located on the Drawings. Coordinate final color selection with Owner.
5. Message: Piping system service name (in full) as indicated in Piping Schedule located on the Drawings. Only the following flow stream abbreviations identified below shall be allowed for pipe labels.
    a. Allowed Pipe Label Flow Stream Abbreviations: NPW.

B. Field Instrument Identification: Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, for labeling requirements for instruments.

C. Equipment Labels:

1. Refer to Section 16075, Electrical Identification, for labeling requirements for electrical equipment including control panels, local control stations, instruments, and motors.
2. Provide identifying nameplate and nametag on new and reused panels and equipment for Existing Panels and Equipment, or as listed elsewhere. Enclosure identification shall be located on the enclosure surface of PLC control panel, motors, pumps, local control stations, instrument transmitters, analytical controllers, etc.
3. Equipment Nameplates and Nametags:
    a. Pumps, valves, gates, and equipment shall be labeled as follows:
        1) Nameplates: Enclosure identification located on the enclosure face with rectangular screw-on nameplates.
        2) Materials: Laminated phenolic plastic nameplates with black background and engraved while lettering.
        3) Fastening: Secure with self-tapping Type 316 stainless steel screws.
        4) Size: 2-1/4-inch high plate.
        5) Text:
            a) Descriptive Name: 1-inch high block lettering.
            b) Descriptive Tag: 1/2-inch high block lettering.
        6) For the same piece of equipment, descriptive nameplate shall be consistently provided at various locations for all associated equipment with that piece.

2.02 SIGN TYPES

A. Metal Sign (Type B):

1. Material: Baked enamel finished 20-gauge (minimum) steel or 18-gauge (minimum) aluminum signs.
2. Manufacturers:
    a. Brady Worldwide, Inc.

b. Seton Identification Products.
c. Nutheme Illustrated Safety Co.

2.03 ANCILLARY MATERIALS

A. Fasteners: Stainless steel screws or bolts of appropriate sizes.

B. Pipe Posts: 2-1/2-inch galvanized steel pipe meeting ASTM A53/A53M, Type S, Grade B.

C. Chain: Type 304 stainless steel, No. 16 single jack chain or No. 2 double loop coil chain.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

A. In accordance with manufacturer's recommendations.

B. Mount securely, plumb, and level.

3.02 SIGNS

A. General:

1. Fasten to walls or posts, or hang as scheduled.
2. Anchor in place for easy removal and reinstallation with ordinary hand tools.

B. Information and Safety Signs:

1. Install facing traffic. Locate for high visibility with minimum restriction of working area around walkways and equipment.
2. Install as scheduled.

3.03 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping as indicated on the Pipe Label Table with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. At wall and floor penetrations on either side of floor and wall.

5. At changes in direction (each side of branches, tee, or elbows).
6. Locate labels at locations observable from normal personnel approach.
7. Application: To pipe only after painting in vicinity is complete or as approved by Engineer.
8. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.04 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Sign Schedule: Tabulation of characteristics and mounting information for signs scheduled. Provide items as scheduled. Meet requirements of Occupational Safety and Health Act (OSHA).

END OF SECTION

Sign Schedule

Sign									Lettering					
			Size			Mounting								
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Color	Location	Method	Height to Top	Height	Style	Color	Message	Faces	Other Requirements
S-1	B	10402	20"	14"	Yellow	Hanging, Post, or Wall	Chain	5'-6"	1" min.	Helvetica	Black	CAUTION Equipment Starts Automatically	1	Provide at equipment that may start automatically and at locations as directed by Field Engineer.
S-2	B	10401	20"	14"	White	Pipe Post	Screws	5'-6"	1" min.	Helvetica	Black	WARNING: EXCESSIVE HEAT DURING PEAK GAS FLOW AND HIGH WINDS. LIMIT ACCESS WITHIN 20 FT OF BURNER	1	At Waste Gas Burner 1
S-3	B	10401	20"	14"	White	Pipe Post or Wall	Bolts	3'-6"	1" min.	Helvetica	Black	DANGER Hazardous Area Possible Toxic Fumes and Lack of Oxygen	1	Provide at spaces that may have toxic fumes and lack of oxygen and at locations as directed by Field Engineer.
S-4	B	10403	20”	14”	White	Pipe Post	Bolts	5’-6”	3”	Helvetica	Black	NO THRU TRAFFIC	1	Provide at locations shown on Civil Drawings.

Sign Schedule

Sign									Lettering					
			Size			Mounting								
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Color	Location	Method	Height to Top	Height	Style	Color	Message	Faces	Other Requirements
S-5	B	10401	20"	14"	White	Pipe Post or Wall	Bolts	3'-6"	1" min.	Helvetica	Black	DANGER No Smoking	1	Provide at entries to spaces with hazardous areas and at locations directed by Field Engineer.
S-6	B	10404	20”	14”	White	Pipe Post	Bolts	5’-6”	3”	Helvetica	Black	RIGHT HAND TURN ONLY	1	Provide at locations shown on Civil Drawings.
S-7	B	10401	20"	14"	White	Pipe Post or Wall	Bolts	3'-6"	1" min.	Helvetica	Black	DANGER Nonpotable Water Not for Drinking	1	Provide at exterior hose valves
S-8	B	10401	10"	7"	White	Wall	Screws	5'-6"	1" min.	Helvetica	Black	DANGER CONFINED SPACE AUTHORIZED EMPLOYEES ONLY	1	At Digester 3 at grade stair landing leading down to bottom accessway

[1]Numbers refer to a particular sign type with a particular message.
[2]Letters refer to Sign Types specified in this section.
[3]Numbers refer to Design Details that show sign layout.

SECTION 11203
IN-LINE SLUDGE GRINDERS

EQUIPMENT AND COMPONENT NUMBER(S)

725GDR6703: Sludge Recirculation Grinder 3.
725GDR6704: Sludge Recirculation Grinder 4.
725GDR6706: Sludge Recirculation Grinder 6.

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. This section covers work necessary to provide three in-line sludge grinders including all appurtenances as specified herein and shown on the Drawings.

B. Electric motors shall be provided as part of the work of this section and comply with Division 16, Electrical.

C. All O&M data, O&M manuals, training requirements, special tools, spare parts, and warranties shall be provided in accordance with Section 01782, Operation and Maintenance Data.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA).
2. American Gear Manufacturers Association (AGMA).
3. American Iron and Steel Institute (AISI).
4. American National Standards Institute (ANSI).
5. ASTM International (ASTM).
6. National Electric Code (NEC).
7. National Electrical Manufacturers Association (NEMA).
8. National Fire Protection Associations (NFPA).
9. UL.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330, Submittal Procedures. In addition, the following specific information shall be provided:

1. Shop Drawings:
   a. Make, model, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction for all components furnished.
   c. Substantiation of motor horsepower selection.
   d. Detailed mechanical and electrical drawings showing the equipment dimensions, size, and weights of associated equipment.
   e. Power and control wiring diagrams, including terminals and numbers.
   f. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
   g. Complete data on motors as specified in Division 16, Electrical.
   h. Factory finish system in accordance with Section 09900, Painting and Coating.
      1) Where system proposed is different from that specified, or where, in the manufacturer's opinion, the coating system(s) proposed exceed(s) the requirements specified, submit the complete technical literature of the proposed system(s) for review.
      2) Where equipment is to be factory-prepared and primed, and field finished, and if manufacturer of finish coating differs from that of shop primer, Contractor shall provide both manufacturers' written confirmation that the prime coat and finish coat are compatible.
2. Informational Submittals:
   a. Factory test report.
   b. Anchorage and bracing calculations, drawings and cut sheets in accordance with Section 01612, Anchorage and Bracing.
   c. A statement indicating and supporting bearing life.
   d. Special shipping, storage and protection, and handling instructions.
   e. Manufacturer's printed installation instructions.
   f. List of spare parts recommended by the manufacturer including part numbers, current price list, and contact for purchasing.
   g. Manufacturer's Certificate of Proper Installation in accordance with Section 01640, Manufacturer's Services and Training.
   h. Operation and Maintenance Manual with Maintenance Summary Form in accordance with Section 01782, Operation and Maintenance Data.

1.04 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Tools and Accessories: Provide one set of special tools and accessories required to install the grinders, assemble and disassemble the grinders, and to perform operation and maintenance activities on the grinders.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage, and handling shall be in accordance with Section 01600, Product Requirements.

B. The containers shall provide adequate protection for the equipment in a dry indoor environment between 40 degrees F and 100 degrees F until time for installation.

1.06 QUALITY ASSURANCE

A. Qualified suppliers shall have a minimum 5 years' experience at manufacturing, two-shafted grinding equipment and controlling equipment with a minimum of 10 installations at equivalents applications. Supplier shall provide a list of names and dates of installations for verification by the Engineer.

B. The manufacturer must certify that the unit can be returned for maintenance to the factory or a local repair facility.

1.07 WARRANTY

A. Manufacturer's warranties shall be per Division 01, General Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. The sludge grinders shall be furnished by a single manufacturer who is fully experienced, reputable, and qualified in the manufacture of the equipment to be furnished. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods. The grinders shall be:

1. Franklin Miller; TaskMaster TM8500 Series.

2.02 SERVICE CONDITIONS

A. Each grinder, under continuous operation, shall be capable of chopping and shredding rags, wood, plastics, and similar materials found in anaerobically digested wastewater sludge originating from municipal wastewater. The small chopped and shredded pieces shall produce a completely homogenized sludge mixture. Grinder feed characteristics:

1. Solids Content: 1 percent to 10 percent.
2. Temperature: 40 degrees F to 110 degrees F.
3. Abrasive.
4. Specific Gravity: 1.

B. Grinders shall be installed on the suction line of the Sludge Recirculation Pumps as shown on the Drawings. Flange connections on the suction and discharge shall be as shown on the Drawings.

2.03 PERFORMANCE REQUIREMENTS

A. The grinders shall have a minimum flow through capacity of 650 gpm.

B. The grinders shall be heavy-duty units capable of operating continuously, processing wet or dry and designed for grinding anaerobically digested sludge into uniform, homogenized slurry. Grinders shall be rated for 150 pounds per square inch gauge (seals 60 pounds per square inch gauge) working pressure. Headloss through the unit shall not exceed 0.5 pounds per square inch at all specified flow rates and solids content.

C. Maximum Discharge Solids Size: 0.4-inch by 0.4-inch by 0.5-inch.

2.04 MATERIALS AND EQUIPMENT

A. Pipe flange adaptors for inline applications shall be 125 pounds. ANSI B16.1 and have gasketed clean out covers for access to the cutting chamber.

B. The main housing shall be a solid cast structure made of ASTM A3950 or ASTM A536 ductile iron. The one-piece flanged body shall be capable of remaining in-line if removal of the cutter cartridge and drive assembly is required for service. The main housing shall maintain a clearance not to exceed 5/16-inch between the major diameter of the cutter and the housing. The main housing shall be provided with a covered access port for equipment inspection. Access port covers shall be of the same material as the main housing.

C. The grinder shall be of the two-shaft design with a minimum output torque of 1,000 inch-pounds and 3,300 inch-pounds at momentary peak loads. The shafts shall counter rotate, and one shaft shall rotate at approximately two thirds the speed of the other shaft. The shaft shall be equipped with spacers and intermeshing cutters OR the cutters shall be a monolithic cutter cartridge type comprising a plurality of 7-tooth cam shaped cutter elements.

D. The grinder shall be constructed of corrosion resistant material to resist corrosion due to cavitation or galvanic action. Shafts shall be constructed from AISI 4140 heat treated steel hexagon stock. Each shaft shall be a minimum of 2 inches. Cutters and spacers shall be cast from AISI 4130 or AISI 4140 heat treated alloy steel, surface ground for uniformity and through hardened to 43-48 Rockwell "C." Alternatively, cutters shall be constructed of AISI 8620 alloy steel and shall be heat treated to produce a hardness of 60-65 Rockwell C, spacers shall be constructed of AISI 8620 alloy steel and shall have a hardness of 34-38 Rockwell C.

E. Each grinder shall be self-cleaning without the use of an external flushing system. Each grinder shall be a straight-through design to minimize clogging.

F. Mechanical shaft seals shall be provided and shall operate on the reverse pressure principle. The radial and axial loads of the shafts shall be borne by oversized Conrad-type (deep-groove) ball bearings. The bearings shall be protected by a combination of replaceable seals and end face mechanical seals. Face materials shall be tungsten carbide, not requiring an external flush or any type of lubrication. The bearings and seals shall be housed in a replaceable cartridge that supports and aligns the bearings and seals, as well as protects the shaft and end housings. O-rings shall be made of Buna-N or EPDM elastomers. Products requiring lubrication or flushing are not acceptable.

G. There shall be a motor speed reducer for each motor. The speed reducer shall be greased for life. Gearing shall be classified for continuous duty, AGMA Class III, 24-hour, heavy shock duty with 2.0 service factor based on motor nameplate rating. The output shaft of the gear reducer shall be directly coupled to the grinder input shaft using a two-piece coupling.

H. Each grinder shall be capable of continuous operation at low or no flow conditions.

2.05 ELECTRICAL EQUIPMENT

General: Electrical equipment shall be in accordance with NEMA standards and NEC requirements.

A. Each drive motor shall be a minimum of 5 hp, 1,760 rpm, 460V, three-phase, 60-Hz and shall meet the requirements of Section 16222, Low Voltage Motors Up to 500 Horsepower. Motor shall be vertical, totally enclosed fan cooled (TEFC) and premium efficiency.

B. NFPA electrical classification for the grinder environment shall be unclassified.

2.06 CONTROLS

A. Grinder control by Contractor. See Drawings and Section 16262 Variable Frequency Drives 0.50-50 Horsepower.

B. Grinder shall be capable of adjustable speed control in both forward and reverse.

2.07 ANCHORAGE

A. Design the anchorage system to secure and support equipment. The anchorage system shall be designed in accordance with Section 01612, Anchorage and Bracing.

B. All anchor bolts, washers, nuts, bolts, and other hardware necessary to secure the system shall be Type 316 stainless steel.

C. Structural computations signed by a professional engineer registered in the State of Oregon shall be submitted for the record.

D. Contractor shall furnish and install anchorage system in accordance with the manufacturer’s drawings and written instructions.

2.08 SURFACE PREPARATION AND SHOP PAINTING

A. All surfaces other than stainless steel shall be prepared and shop primed as part of the Work of this section. Surface preparation and shop priming shall be System No. 4 as specified in Section 09900, Painting and Coating. The shop primer shall be compatible with the finish field paint.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Grinders shall be rigidly supported on concrete pads. Installation shall include furnishing the required grease and/or oil for initial operation. The grades of grease and/or oil lubricants shall be in accordance with the manufacturer's recommendations.

3.02 FIELD FINISHING

A. Equipment shall be coated as specified in Section 09900, Painting and Coating, System No. 4. Contractor shall coordinate with manufacturer to provide a finish coat which is compatible with the factory applied prime coat. If the manufacturer of finish coating differs from that of shop primer, provide both manufacturer's written confirmation that materials are compatible.

3.03 INSPECTION AND TESTING

A. Furnish the services of a factory representative, who has complete knowledge of proper operation and maintenance to inspect and adjust the installed equipment prior to operation of the units and to final inspect the final installation and supervise a test run of the equipment.

B. After the grinders and their associated pumps are installed and their piping completed and ready for operation, conduct in the presence of the Engineer or Owner's Representative and under the supervision of the manufacturer's factory representative, test runs using water to demonstrate the unit's ability to operate as specified, without noise, vibration or overheating. Any deficiencies noted during the testing shall be corrected at no additional cost to the Owner.

C. When digested sludge becomes available, another test shall be made in the presence of the Engineer or Owner's Representative under regular operating conditions, to further demonstrate that the grinder performance conforms to this section. It shall also be demonstrated that each grinder control system performs as specified.

D. The grinder will not be accepted until the grinder passes a 1-month performance test under normal operating conditions with digested sludge. If the grinder shuts down due to a jam condition four times during the 1-month performance test, the grinder will be considered unacceptable. The manufacturer shall be permitted to modify the equipment completely at the manufacturer's expense and the tests repeated as described above.

3.04 MANUFACTURER'S SERVICES

A. Provide Manufacturer's Representative in accordance with Section 01640, Manufacturers Services and Training. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1-person-day for installation assistance and inspection.
2. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.05 MANUFACTURER'S CERTIFICATION OF PROPER INSTALLATION

A. The Contractor shall provide manufacturer's Certification of Proper Installation in accordance with Section 01330, Submittal Procedures.

END OF SECTION

SECTION 11311
NON-CLOG DRY-PIT CENTRIFUGAL PUMPS

EQUIPMENT AND COMPONENT NUMBER(S)

725P6703: Sludge Recirculation Pump 3.
725P6704: Sludge Recirculation Pump 4.
725P6706: Sludge Recirculation Pump 6.

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings:
      1) Class 25, Class 125, and Class 250.ASTM International (ASTM): A48/A48M, Standard Specification for Gray Iron Castings.
3. Hydraulic Institute (HI) Standards:
   a. 9.6.4, Rotodynamic Pumps for Vibration Measurements and Allowable Values.
   b. 11.6, Rotodynamic Submersible Pumps for Hydraulic Performance, Hydrostatic Pressure, Mechanical, and Electrical Acceptance Tests.
   c. 14.6, Rotodynamic Pump for Hydraulic Performance Acceptance Tests.
4. International Organization for Standardization (ISO): 21940 Series and particularly Mechanical Vibration – Rotor Balancing – Part 11 Procedures and Tolerances for Rotors with Rigid Behavior.
5. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
6. Occupational Safety and Health Administration (OSHA).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330, Submittal Procedures. In addition, the following specific information shall be provided:

1. Action Submittals:
   a. Shop Drawings:
      1) Make, model, weight, and horsepower of each pump assembly.
      2) Complete pump and motor catalog information, descriptive literature, specifications, and identification of materials of construction for all components furnished.
      3) Plan and section dimensional outline drawings of the pumps and motors identifying all components, anchor bolts, external connections, and appurtenances. Include all components identified with quantity, part name and corresponding materials of construction complete with ASTM designation on sectional drawings.
      4) Performance data curves showing head, capacity, horsepower demand, net positive suction head required (NPSH3), and pump efficiency over entire operating range of pump, from shutoff to maximum capacity.
         a) Include the pump's preferred operating range (POR) and the manufacturer's defined maximum allowable operating range (AOR) for continuous steady state service on performance curves.
         b) Indicate separately head, capacity, horsepower demand, NPSH3, and overall efficiency required at the AOR's minimum and maximum continuous stable flow conditions and at the Rated Conditions and at Secondary Conditions (if applicable).
      5) Certified detail structural, mechanical, and electrical drawings showing equipment dimensions, arrangement, assembly, including locations and type of connections and weights of major equipment and components.
      6) Lateral and torsional critical speed analysis.
      7) Structural response frequency analysis.
      8) Power and control wiring diagrams, including terminals and numbers.
      9) Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
      10) Factory finish system.
      11) Bearing life calculation confirming compliance with L10 bearing life requirement.

12) Seismic anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

2. Informational Submittals:
   a. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
   b. Manufacturer's design analyst qualifications.
   c. Special shipping, storage and protection, and handling instructions.
   d. Manufacturer's printed installation instructions.
   e. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements, that factory finish system is identical to requirements specified herein.
   f. Factory Functional and Performance Test Reports and Log.
   g. Field Vibration and Performance Test Reports.
   h. Manufacturer's Certificate of Proper Installation, in accordance with Section 01640, Manufacturers' Services and Training.
   i. Suggested spare parts list to maintain equipment in service for period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
   j. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
   k. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data.

1.04 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Tools and Accessories: Provide one set of special tools and accessories required to install the pump, assemble and disassemble the pump, and to perform operation and maintenance activities on the pump.

C. Delivery: In accordance with Section 01600, Product Requirements.

1.05 WARRANTY

A. The manufacturer shall warrant the equipment to be free of defects in design, material, and workmanship for a period of 1-year from the date of acceptance or 18 months after equipment delivery to the Project Site, whichever occurs first.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide a complete, coordinated, and fully functional operating system.

B. Coordinate pump requirements with motor manufacturer and be responsible for pump and motor requirements.

C. Pumps supplied under this section to be a standard product of manufacturer and to have proven reliability.

D. Provide a complete lateral and torsional critical speed analysis of each pump-coupling-motor rotating assembly and structural analysis of complete pump and motor assembly performed by pump manufacturer or qualified third party.

1. Analyst Qualifications: Experienced in performing analyses for pump and motor units of comparable size and complexity.
2. Prepare a written report for each completed analysis documenting analysis and calculation procedures.
3. Submit results of each analysis for review and acceptance prior to pump and motor fabrication.

E. Lateral Analysis:

1. Identify lateral critical speeds for both pump and motor shafts.
2. Include both dry and wet impeller cases.
3. Provide a critical speed map demonstrating that a critical speed does not occur below 1.25 times the maximum rated speed of the pump and motor and does not occur between 0.75 times the blade pass frequency associated with the minimum speed of the pump and 1.25 times the blade pass frequency associated with the maximum specified speed of the pump.
4. Calculate the damped vibration response to unbalance for the shafts and compare to applicable specified requirements to verify acceptable vibration amplitudes.

F. Torsional Analysis:

1. Calculate system torsional natural frequencies, corresponding mode shapes, and steady-state and transient torsional response.
2. Provide an interference diagram demonstrating the following:
   a. No critical speeds occur between 0.80 times the minimum specified operating speed and 1.20 times the maximum rated speed of the pump and motor.

b. No critical speed associated with the mechanical running speed (one times shaft speed) excitation frequency occurs below 1.20 times the maximum rated operating speed.

3. Forced Response Analysis:
   a. Perform a forced response analysis for all critical speeds determined to occur below 1.20 times the maximum rated operating speed.
   b. Expected excitation frequencies for steady-state operation include as a minimum, but not limited to, electrical line frequency, two times electrical line frequency, current modulating frequencies produced by the variable frequency drive, mechanical running speed (one times shaft speed), two times mechanical running speed (two times shaft speed), and blade pass frequency.
   c. Confirm that calculated steady-state and transient dynamic torsional shaft stresses and coupling torques are below allowable levels, such that the motor shaft, pump shaft, and associated drive train components are capable of an unlimited number of startup and shutdown cycles associated with 0 rpm up to the maximum rated speed.
   d. Include a factor of safety of at least two in the allowable stress levels and demonstrate stresses on a Modified Goodman Diagram.
   e. Confirm that dynamic torque in the couplings is in accordance with coupling manufacturer’s requirements.

G. Structural Response Frequency Analysis:

1. Perform a structural response frequency analysis for the pump and motor assembly.
2. At a minimum, model the motor, pump, and fabricated support, including any other critical components based upon mounting details shown on the Drawings.
3. Confirm that the minimum structural natural frequency of the complete pump and motor assembly is a minimum of 1.25 times the maximum rated pump and motor speed and does not occur between 0.75 times the blade pass frequency associated with the minimum speed of the pump and 1.25 times the blade pass frequency associated with the maximum specified speed of the pump.
4. Verification of calculated natural frequencies of the pump and motor assembly shall be performed by pump manufacturer, or pump manufacturer’s authorized representative, when unit is fully installed at the Project Site.

2.02 SUPPLEMENTS

A. Specific service, performance, and design requirements are attached to this section as supplements.

2.03 EQUIPMENT

A. Pump:

1. Heavy-duty, solids handling, non-clog, dry pit design.
2. Configuration: See Supplements.
3. See the Drawings for pump orientation and rotation.
4. Continuously rising head-capacity curve from runout to shutoff.
5. Designed to operate continuously at any point on specified operating range of performance curve without cavitation, overheating, or excessive vibration.
6. Motor nameplate horsepower rating not to be exceeded by pump brake horsepower required at any point on nominal pump performance curve.

B. Casing:

1. Back pullout design allowing for removal of rotating element without disturbing piping connections.
2. Heavy wall, one-piece volute construction with integral flanged discharge flange and smooth fluid passages. Provide drilled and tapped volute priming and drain connections.
3. Wear ring securely fastened to casing (or suction cover) with recessed stainless-steel screws.
4. Provide handhole for cleanout purposes at volute centerline located to provide access to interior of pump.
5. Flanges:
   a. Conform to ASME B16.1, Class 125-pound, flat face standard.
   b. Provide 1/2-inch gauge connection drilled and tapped in discharge flange.
6. Diffusion vanes or stationary guides are not allowed.

C. Suction Cover (Fronthead):

1. Single-piece construction designed to provide even flow to impeller eye.
2. Flanged connection conforming to ASME B16.1, Class 125-pound, flat face standard.
3. Machine register fitted to casing.

D. Suction Elbow:

1. ASME B16.1, Class 125-pound flat face standard, flanged suction elbow with contoured handhole cleanout and cover.
2. Provide 1/2-inch gauge connection.

E. Stuffing Box Cover (Backhead):

1. Single-piece construction designed with integral stuffing box suitable for use of either conventional packing or mechanical seal. Drilled and tapped 3/4-inch drain connection and large openings to allow easy access to stuffing box.
2. Designed for installation of a minimum of five rings of packing and a split type lantern ring and a split type gland follower. Provide stuffing box with 1/4-inch minimum drilled and tapped connection for injection or venting of the stuffing box.
3. Machine register fitted to casing.

F. Bearing Frame and Bearings:

1. Removable, single-piece construction.
2. Machined for accurate bearing alignment and completely enclosing shaft between bearings.
3. Provide with retainer covers on inboard and outboard ends of frame equipped with lip-type grease seals to prevent entrance of contaminants.
4. Single or double row bearings at inboard and outboard ends designed to take radial, weight, and thrust loads of pump and associated shafting loads. Bearings to be designed for an L10 life per ABMA at best efficiency point.
5. Provide jacking screws for adjustment of impeller.
6. Grease packed at factory and provided with grease fittings for bearing lubrication.

G. Impeller:

1. Single suction, enclosed, non-clogging type design with extremely smooth passageways to prevent clogging.
2. Single-piece construction.
3. Secure to shaft with stainless steel bolt, washer, and key to prevent loosening from either forward or reverse rotation.
4. Dynamically balanced to assure vibration limits for pump are not exceeded.
5. Wear ring securely fastened to impeller with recessed stainless-steel screws. Impeller wear ring to be a minimum of 50 Brinell softer than suction head wear ring.

H. Shaft:

1. Accurately machined over entire length and precision ground at bearing, stuffing box, and bearing housing seal locations such that shaft or sleeves roughness shall not exceed 32 microinches full indicator movement.
2. Designed to transmit full motor horsepower with a liberal safety factor to carry maximum loads imposed and to meet pump vibration requirements.
3. Shaft runout on stuffing box or seal chamber face and at impeller shall exceed 0.002-inch full indicator movement.
4. Provide keyways at both ends.
5. Provide renewable, hooked shaft sleeve positively secured to shaft to prevent leakage.

I. Pump Base: Rugged, heavy duty, with ample strength for support of entire pump and imposed static and operational loads.

J. Coupling:

1. Designed to provide flexible connection between pump and motor.
2. Flexible coupling to be designed to carry maximum horsepower of motor, including service factor, and additional forces imposed by rotating assembly.
3. Flexible coupling selection to take into account torsional analysis of complete pump and motor drive system. There is to be no torsional critical speed within specified speed range. Number of vanes times the rpm is part of this speed range.
4. Provide fabricated coupling guard to comply with OSHA safety standards.

K. High Ring Base:

1. Cast iron or fabricated steel of adequate height to allow access to flexible coupling and designed to carry weight of motor without undue vibration to pump assembly.
2. Provide with shaft guard to comply with OSHA safety standards.

L. Extension Shaft Assembly:

1. Constructed of sufficient diameter and properties to transmit 1.25 times full motor horsepower including service factor.
2. Complete with self-leveling, self-aligning universal joint at pump end, and coupled to meet motor connection requirements at motor end.

3. Pump thrust bearing to be designed to carry weight of lower portion of universal joint assembly and any imposed lateral loads plus loads from pump rotating assembly and hydraulic thrust to meet required L10 bearing life.
4. Motor thrust bearing to be designed to carry weight of universal joint extended shaft assembly and motor coupling to meet required L10 bearing life.
5. Designed to allow shaft to be disconnected to swing to the side for removal of rotating assembly.
6. Provide shaft guard to conform to OSHA safety requirements; complete with banded openings to allow access to shaft lubrication fittings.

2.04 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Provide 16-gauge, Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 1/4-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications. Coat in accordance with Section 09900, Painting and Coating.

2.05 FACTORY FINISHING

A. Manufacturer to prepare, prime and finish coating accordance with Section 09900, Painting and Coating, System No. 4.

2.06 SOURCE QUALITY CONTROL

A. Factory Tests and Adjustments:

1. Factory testing to be in accordance with the standards of the Hydraulic Institute, latest edition.
   a. Pump Test Acceptance Grade for Rated Duty Point: 1U.
2. Test all pumps actually furnished. Use manufacturer’s standard test motor for factory tests.
3. Factory tests to include the following:
   a. Performance testing of fully assembled pump, per Hydraulic Institute Standard 14.6. Performance testing to be at rated speed.

b. Dynamically balance rotating assembly to ISO 21940-11 Grade G6.3 or better prior to final assembly.
c. Vibration testing of fully assembled pump with the Project motor at full rated speed.
    1) Limits of Vibration of Fully Assembled Pump: Less than 90 percent of those established in standards of the Hydraulic Institute.
d. Include complete test records performance curves certified correct by an authorized representative of the pump manufacturer of each test performed.
e. Motor Test: See Section 16222, Low Voltage Motors Up to 500 Horsepower.
f. Make necessary adjustments, realignments, and retest to bring pumps into compliance.
g. Witnessing of factory testing shown on supplements at end of this section.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4-inch per foot. Use double wedges to provide level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, non-shrinking grout of the proper category. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05500, Metal Fabrications.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09900, Painting and Coating, System No. 4.

3.03 FIELD QUALITY CONTROL

A. Functional Tests:

1. Conduct on each pump, system, and subsystem as specified in Section 01756, Testing and Facility Startup.
2. Alignment:
    a. Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
    b. Verify alignment of complete extended shaft assembly, including angularity of pump and motor shafts, meets requirements of shafting manufacturer.
        1) Alignment shall be completed by third party (OTS precision balancing or similar) via laser.
        2) Provide printed report of completed alignment.
    c. Shafting manufacturer’s authorized representative shall verify installation alignment and prepare and submit a report confirming compliance.
3. Flow Output: Measure using plant instrumentation and storage volumes.
4. Operating Temperatures Monitor bearing areas on pump and motor abnormally high temperatures vibrations.
5. Vibration Test:
    a. Test with units installed and in normal operation and discharging to connected piping systems at rates at 20 percent speed increments over the anticipated operating speed range of the pump and with actual building structures and foundations provided.
        1) Confirm vibration is below 90 percent of limits specified in HIS 9.6.4.
    b. If units exhibit vibration in excess of the limits specified adjustor modify as necessary to bring units into compliance. Units that cannot be adjusted or modified to conform as specified shall be replaced.
    c. Provide instrumentation in current calibration to measure pump vibration at locations outlined in the Hydraulic Standards.
    d. Prepare test report, including test records for each pump.
6. Performance Test: Conduct on each pump as specified in Section 01756, Testing and Facility Startup.
7. Test in accordance with Hydraulic Institute Standard 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
8. Perform under simulated operating conditions at full rated speed.

9. Test for a continuous 3-hour period without malfunction.
10. Test Records and Report: Prepare and submit a complete test report along with the test records in accordance with Hydraulic Institute Standard 14.6.
11. Use of plant instrumentation is allowed for tests. Provide additional instrumentation required to obtain required test data per the Hydraulic Institute.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:
   a. 1-person-day for installation assistance and inspection.
   b. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Sludge Recirculation Pumps 3, 4, and 6 Pump Data Sheet.
2. Sludge Recirculation Pumps 3, 4, and 6 Drive Induction Motor Data Sheet.

END OF SECTION

SLUDGE RECIRCULATION PUMPS 3, 4, AND 6 PUMP DATA SHEET

Service: Digested Sludge
Pump Name: Sludge Recirculation Pumps 3, 4, and 6
Pump Tag Number(s): 725P6703, 725P6704, 725P6706
No. Pumps Required [including spares]: 3

Pump A Mfr.: Worthington
Model No.:
Pump B Mfr.:
Model No.:
Pump C Mfr.:
Model No.:
Pump D Mfr.:
Model No.:

LIQUID PUMPED AND SERVICE CONDITIONS

Liquid Pumped: Digested Sludge (DSL)
Pumping Temperature (°F):
Normal: 95 Max: Min:
Specific Gravity @ 60°F:
Liquid pH:
Solids Content: 2-6%
Max Diameter Solid Pump Can Pass (in): 0.4 inch
Min NPSH Available (ft): 62
Suction Pressure (ft): Max: Rated:
Erosion/Abrasion/Corrosion: ☒ Yes ☐ No
Caused by:
Scale Buildup: ☐ Yes ☐ No
Caused by:
Ambient Temp (°F): Max: 90 Min: 65
Altitude (ft above MSL):
Location: ☒ Indoor: ☐ Heated ☐ Unheated ☐ Outdoor
Area Classification: NA

PERFORMANCE REQUIREMENTS

Capacity Rated (U.S. gpm): 650
TDH Rated (ft): 35
NPSH Required (ft):
3% Head Drop (ft):
Max Shutoff Pressure (ft): 50
Efficiency Rated (%):
Speed Rated Capacity (rpm):
☒ Constant ☐ Adjustable

Remarks:

SLUDGE RECIRCULATION PUMPS 3, 4, AND 6 PUMP DATA SHEET (CONTINUED)

PUMP DESIGN	**PUMP MATERIALS**
Configuration: ☒ Horizontal, Frame Mounted ☐ Vertical, Close-Coupled ☐ Vertical, Extension Shafting	Casing: ☐ Cast Iron ASTM A48/A48M Cl 30 ☐ Cast Iron ASTM A48/A48M Cl 35 ☒ With 3% Nickel
Nozzle Size (inches): Suction: 6" Discharge: 6"	Impeller: ☐ Cast Iron ASTM A48/A48M Cl 30 ☒ With 3% Nickel
Casing: ☐ Single Volute ☐ Tangential Discharge ☒ Centerline Discharge	Suction Elbow: ☐ Cast Iron ASTM A48/A48M Cl 30 ☒ With 3% Nickel
Impeller: ☐ Enclosed ☐ Two Vane ☐ Three Vane ☐ Bladeless	Shaft: ☐ High Strength Steel ☐ ANSI 1045 Steel, HR ☐ Type 4140 Alloy Steel ☒ Type 304 Stainless Steel
Wear Ring: ☐ Suction Cover ☒ Impeller ☐ Axial Type ☐ Radial Type ☐ L Type	Shaft Sleeve: ☐ Hardened Stainless Steel ☐ Corrosion-Resistant Bronze
Bearing: ABMA L-10 Life (hrs.): Lubrication: ☐ Grease ☒ Oil	Wear Ring: ☐ Hardened Stainless Steel
Shaft Sleeve: ☐ Yes ☐ No	Packing: ☐ Graphite Impreg. Braided Synthetic
Pump Base: ☐ Heavy Duty Fabricated Steel ☐ Cast Iron Combination Base Elbow ☐ Cast Mounting Pads with Casing	Lantern Ring: ☐ Bronze ☐ Teflon
Suction Elbow: ☐ Yes ☐ No Type:	Follower Gland: ☐ Bronze ☐ Cast Iron ☐ Steel
Coupling: ☒ Standard Flexible Type ☐ Spacer Type Manufacturer: Rexnord, Omega	Mechanical Seal: ☒ Buna N ☐ Viton ☐ EPT ☐ Carbon ☐ Tungsten Carbide ☐ Silicone Carbide ☐ 18-8 Stainless Steel ☐ Type 316 Stainless Steel ☒ Cartridge (John Crane, "or-equal")
Shaft Seal: ☐ Packing ☒ Mechanical Type: Cartridge Manufacturer: John Crane Seal lubrication: Non-potable water	Extension Shafting: ☐ Steel ☐ Fiber Reinforced Composite
Extension: ☐ Solid ☐ Tubular	Pump Coating System: Per Section 09900, Painting and Coating
Shafting: Number of segments: Max Drive Shaft Seg Length (in):	

Remarks:

SLUDGE RECIRCULATION PUMPS 3, 4, AND 6 PUMP DRIVE
INDUCTION MOTOR DATA SHEET

Pump Name: Sludge Recirculation Pumps 3, 4, and 6

Pump Tag Number(s): 725P6703, 725P6704, 725P6706

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 10

Voltage: 480

Phase: 1

Frequency: 60

Synchronous Speed (rpm): _____

Inverter Duty: ☒ Yes ☐ No

☐ Thermal Protection: _____

☐ Space Heater: _____ volts, single-phase

☐ Moisture Detection Switches

☐ Thermal Protection Embedded in Windings

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☒ 1.0 ☐ 1.15

Enclosure Type: ☐ DIP ☐ EXP ☐ ODP ☒ TEFC
☐ CISD-TEFC ☐ TENV ☐ WPI ☐ WPII ☐ SUBM

☐ Multispeed, Two-Speed: _____ / _____ rpm
Winding: ☐ One ☐ Two

Mounting Type: ☒ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☐ Non-reverse Ratchet

☐ Adjustable Speed Drive: See Section 16222, Low Voltage Motors Up to 500 Horsepower.

Operating Speed Range: _____ min to: _____ max

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 16222, Low Voltage Motors Up to 500 Horsepower.

Special Features:

_____

_____

_____

SECTION 11315
PROGRESSING CAVITY PUMPS

EQUIPMENT AND COMPONENT NUMBER(S)

715P6406: FOG Waste Feed Pump 3.

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA).
2. Hydraulic Institute Standards (HIS).
3. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330, Submittal Procedures. In addition, the following specific information shall be provided:

1. Action Submittals:
   a. Shop Drawings:
      1) Make, model, weight, and horsepower of each equipment assembly.
      2) Complete catalog information, descriptive literature, specifications, and identification of materials of construction of all components furnished.
      3) Performance data curves showing head, capacity, horsepower demand, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the guarantee point.
      4) Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size, and locations of connections and weights of associated equipment.

5) Power and control wiring diagrams, including terminals and numbers.
6) Motor data in accordance with requirements of Section 16222, Low Voltage Motors Up to 500 Horsepower.
7) Factory finish system.
8) Manufacturer's Certification of Compliance that factory finish system is identical to the requirements specified herein.
9) L-10 bearing life calculations per ABMA.
10) Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

2. Informational Submittals:
   a. Anchorage and bracing calculations signed by a structural professional engineer licensed in Oregon and as required by Section 01612, Anchorage and Bracing.
   b. Factory Performance Test Reports and Log.
   c. Special shipping, storage and protection, and handling instructions.
   d. Manufacturer's printed installation instructions.
   e. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
   f. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
   g. Operation and Maintenance Data: As specified in Section 01782, Operation and Maintenance Data.
   h. Manufacturer's Certificate of Proper Installation in accordance with Section 01640, Manufacturers' Field Services.
   i. Field Performance Test Reports.

1.04 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Tools and Accessories: Provide one set of special tools and accessories required to install the pump, assemble and disassemble the pump, and to perform operation and maintenance activities on the pump.

C. Delivery: In accordance with Section 01600, Product Requirements.

1.05 WARRANTY

A. The manufacturer shall warrant the equipment to be free of defects in design, material, and workmanship for a period of 1 year from the date of acceptance or 18 months after equipment delivery to the Project Site, whichever occurs first.

PART 2 PRODUCTS

2.01 GENERAL

A. Coordinate pump requirements with motor and adjustable speed drive manufacturer and be responsible for pump, motor, and drive requirements.

B. Pumps furnished under this section shall be provided by a single manufacturer.

2.02 ACCESSORIES

A. Stator Thermal Protection:

1. Provide for pumps where indicated in supplements and as specified below:
   a. Stator thermal protection (run dry protection) shall shut pump down before stator damage occurs.
   b. Provide thermowell drilled and tapped into stator and thermocouple for measurement of temperature at pump stator to rotor interface.
   c. Provide temperature controller in Type 304 stainless steel NEMA 4X enclosure, with dual display for stator temperature and alarm set-point with adjustable hysteresis to prevent on/off cycling of pump when coming off an alarm.
   d. Provide thermocouple cable between thermocouple and temperature controller.
   e. Temperature Controller Output: Dry contact SPDT rated for 5 amps at 120V ac. Contact closes at high temperature to stop pump.
   f. Temperature Controller Power Supply: 120V ac.

B. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

C. Lifting Lugs: Equipment weighing over 100 pounds.

D. OSHA-approved guard for direct coupled or belt driven pumps.

E. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications, and in accordance with Section 09900, Painting and Coating.

2.03 FACTORY FINISHING

A. Prepare, prime, and finish coat in accordance with Section 09900, Painting and Coating, System No. 4.

2.04 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment and control panels furnished.

C. Factory Test Report: Include test data sheets, curve test results, performance test logs, certified correct by a registered professional engineer.

D. Functional Test: Perform manufacturer’s standard test on equipment.

E. Motor Test: See Section 16222, Low Voltage Motors Up to 500 Horsepower.

F. Performance Test:

1. Conduct on each pump.
2. Conduct in accordance with Hydraulic Institute Standards
3. Perform under simulated operating conditions.
4. Test for a continuous 1-hour period without malfunction.
5. Test Log:
    a. Record the following:
        1) Pump speed.
        2) Inlet pressure.
        3) Outlet pressure.
        4) Differential pressure.
        5) Total head.
        6) Capacity.
        7) Flow rate measured by factory instrumentation and storage volumes.
6. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of the baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03600, Grouting. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05500, Metal Fabrications.

G. Pipe pump drain(s) to hub drain.

3.02 FIELD FINISHING

A. Touch up finish coat in accordance with Section 09900, Painting and Coating, System No. 4. Contractor shall repair and refinish painted surfaces as required.

3.03 EQUIPMENT TESTING AND FACILITY STARTUP

A. Equipment testing and facility startup shall be in accordance with the requirements of Section 01756, Testing and Facility Startup.

B. Facility startup specifies order and prerequisites for the following tests of the equipment:

1. ORT 1 testing.
2. Field functional testing.
3. ORT 2 testing.
4. Performance testing.
5. Demonstration testing.

C. Field testing and facility startup shall be performed using a qualified representative provided by the manufacturer as specified in Section 01756, Testing and Facility Startup, and Section 01640, Manufacturer's Field Services, and as specified herein.

3.04 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Test for a continuous 1-hour period without malfunction.
3. Flow Output: Measured by plant instrumentation and storage volumes.
4. Verify the following functions of stator thermal protection device:
   a. Stator temperature high setpoint is configured to proper value for pump provided.
   b. Interlock activates when stator temperature reaches high setpoint and inhibits pump form running in all modes.
   c. Interlock resets/releases when stator temperature drops below the hysteresis value.

B. Submit completed Manufacturer's Certificate of Proper Installation.

C. Performance Test:

1. Conduct on each pump as part of Facility Startup.
2. Test for continuous 4-hour period.
3. Operate across specified range of flows, pumping specified media.
4. Record flow rate, suction pressure, discharge pressure, and motor amp draw at approximate 1/2-hour intervals and as needed to record operation over specified range of flows.

3.05 MANUFACTURER'S SERVICES

A. See Section 01640, Manufacturers' Field Services and Training.

B. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for performance testing and facility startup.

3.06 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. FOG Waste Feed Pump 3 Data Sheet.
2. FOG Waste Feed Pump 3 Drive Induction Motor Data Sheet.

END OF SECTION

FOG WASTE FEED PUMP 3 DATA SHEET

Service: FOG
Pump Name: FOG Waste Feed Pump 3
Pump Tag Number(s): 715P6406
No. Pumps Required: 1

Pump A Mfr.: SEEPEX
Model No.: BN 17-6LS

Liquid Pumped and Service Conditions

Liquid Pumped: FOG
Pumping Temperature (°F):
Normal: 80 Max: 100 Min: 50
Specific Gravity @ 60°F: 1.0
Viscosity Range (CP) @ 60°F: 1-5 CP
Liquid pH: 2
Min NPSH Available (psia):
Erosion/Abrasion/Corrosion: ☒Yes ☐No
Caused by:
Scale Buildup: ☐Yes ☒No
Caused by:
Ambient Temp (°F): Max: 90 Min: 60
Altitude (ft above MSL):
Location: ☒Indoor: ☐Heated ☐Unheated ☐Outdoor
Area Classification: NA

Performance Requirements

Capacity Rated (U.S. gpm): 26
RANGE (US gpm): 10-50
TDH Rated (psig): 40
NPSH Required (psig):
Max Speed Rated (rpm): 250
☐Constant ☒Adjustable
Speed Range of Rated Speed (%): 10-110
Constant Torque: ☐Yes ☐No
Motor (per Section 16222, Low Voltage Motors Up to 500 Horsepower.
Horsepower: 5
Base Speed (rpm): 1,800
Voltage: 460 Phase: 3 Hz: 60
Service Factor: 1.0
Inverter Duty: ☒Yes ☐No
Enclosure:
☐DIP ☐EXP ☐ODP ☒TEFC ☐TENV
☐CISD-TEFC ☐WPI ☐WPII ☐SUBM

Remarks: Provide motor with isolated bearings and shaft grounding. Mount pump and motor to common carbon steel baseplate.

FOG WASTE FEED PUMP 3 DATA SHEET (CONTINUED)

Pump Design and Materials (Manufacturer to Supply Missing Data)

Connections:
- Suction size (inches): 2
  - ☒ Flanged Type: _____
  - ☐ Open-Throat
  - ☐ Screwed
- Orientation: **TOP ENTRY AS SHOWN ON THE DRAWINGS**
- Discharge size (inches): 2
  - ☒ Flanged Type: _____
  - ☐ Screwed

Pump Body:
- Material: Cast iron

Drive Housing:
- Material: Cast iron

Pump Stages: 1

Suction Port:
- Material: _____

Stator:
- Material: NBR - Perbunan
- Type: Split
- Thermal Protection: ☒ Yes ☐ No

Rotor:
- Material: Type 316 stainless steel

Connecting Rod:
- Material: Type 420 stainless steel

Drive Shaft:
- Material: Type 420 stainless steel

Joint:
- ☒ Gear Type Universal
- ☐ Pin Type Universal
- ☐ Other Type: _____

Shaft Sleeve: ☐ Yes ☐ No:
- Material: _____

Shaft Seal:
- ☐ Packing Material: _____
- ☐ Lantern Ring Material: _____
- ☒ Mechanical Type: John Crane SAB 55
  - Material: _____
- Seal lubrication: Non Potable Water

Bearing:
- ABMA B-10 Life (hrs): 10,000
- Lubrication: ☐ Grease ☐ Oil

Coupling:
- ☐ Mfr Standard
- ☐ Falk
- ☐ Fast
- ☐ Gear Type

Baseplate:
- Design: Fabricated
- Material: Carbon steel

Drive Type:
- ☒ Direct-Coupled
- ☐ Belt
- ☐ Close-Coupled Gear Reducer
- ☐ Bearing-Frame Gear Reducer Drive

Arrangement: ☒ In-Line ☐ Piggy Back
- ☐ Horizontal Offset ☐ Vertical "Z"

Remarks: _____

FOG WASTE FEED PUMP 3 DRIVE
INDUCTION MOTOR DATA SHEET

Pump Name: FOG Waste Feed Pump 3

Pump Tag Number(s): 715P6406

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 5

Voltage: 460

Phase: 3

Frequency: 60

Synchronous Speed (rpm): _____

Inverter Duty: ☒ Yes ☐ No

☐ Thermal Protection: _____

☐ Space Heater: _____ volts, single-phase

☐ Moisture Detection Switches

☐ Thermal Protection Embedded in Windings

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☒ 1.0 ☐ 1.15

Enclosure Type: ☐ DIP ☐ EXP ☐ ODP ☒ TEFC

☐ CISD-TEFC ☐ TENV ☐ WPI ☐ WPII ☐ SUBM

☐ Multispeed, Two-Speed: _____/_____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☐ Non-reverse Ratchet

☒ Adjustable Speed Drive: See Section 16262, Variable Frequency Drives 0.50-50 Horsepower.

Operating Speed Range: _____ min to: _____ max

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 16222, Low Voltage Motors Up to 500 Horsepower.

Special Features:

Provide motor with isolated bearings and shaft grounding.

SECTION 11382
SLUDGE HEAT EXCHANGER

EQUIPMENT AND COMPONENT NUMBER(S)

725HX6703: Heat Exchanger 3.

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   b. BPVC (boiler and pressure vessel code) 2023.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, and weight of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Detailed structural and mechanical drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment.
   d. Factory finish system.
   e. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing, signed by licensed structural Oregon professional engineer.
2. Certificate of Compliance with ASME Code Section VIII, Division 1.
3. Manufacturer’s Certificate of Compliance, in accordance with Section 01600, Product Requirements, that factory finish system is identical to the requirements specified herein.
4. Factory Functional Test Report.
5. Special shipping, storage and protection, and handling instructions.
6. Manufacturer’s printed installation instructions.
7. Field Performance Test Report.

8. Operation and Maintenance Data: As specified in Section 01782, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01640, Manufacturers' Services and Training.

1.03 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing to maintain the equipment in service for a period of 5 years.

B. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

C. Tools and Accessories: Provide one set of special tools and accessories required to install the heat exchanger, assemble and disassemble the heat exchanger, and to perform operation and maintenance activities on the heat exchanger.

D. Delivery: In accordance with Section 01600, Product Requirements.

1.04 WARRANTY

A. The manufacturer shall warrant the equipment to be free of defects in design, material, and workmanship for a period of 1-year from the date of acceptance or 18 months after equipment delivery to the Project Site, whichever occurs first.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alfa Laval.
2. No exceptions or substitutions.

B. Equipment supplied shall be manufactured to match the dimensions and nozzle locations and sizes of the existing units, 20M10301 Heat Exchanger 1 and 20M10302 Heat Exchanger 2. Existing heat exchanger data sheet is included as supplemental to this specification.

2.02 EQUIPMENT

A. Heat exchanger shall be spiral type with outer thickness 0.25-inch.

2.03 SYSTEM PERFORMANCE

A. Sludge Side:

1. Flow: 650 gpm.
2. Temperature:
   a. Inlet: 95 degrees F.
   b. Outlet: 102 degrees F.
3. Operating Pressure: 30 pounds per square inch gauge.
4. Maximum Pressure Loss: 2.5 pounds per square inch to 3 pounds per square inch.

B. Water Side:

1. Flow: 270 gpm.
2. Temperature:
   a. Inlet: 165 degrees F.
   b. Outlet: 150 degrees F.
3. Operating Pressure: 50 pounds per square inch gauge.
4. Maximum Pressure Loss: 2.5 pounds per square inch to 3 pounds per square inch.

C. Design Pressure: 50 pounds per square inch gauge.

D. Fouling Factor Allowance: 0.001-hour square foot /Btu.

2.04 MATERIALS

A. Exchanger: Carbon steel SA-516-70, seamless coil construction.

B. Nozzles: ASME B16.1, Class 150 flange. Sizes are to match existing heat exchangers as shown in data sheet supplemental to this specification.

C. Gaskets: Full-face neoprene sheet minimum 0.125-inch thick.

D. Connections: Couplings for temperature and pressure gauges, 1-inch NPT drain with valves, and a 4-inch hand hole clean out port.

2.05 ACCESSORIES

A. Provide with mounting feet suitable for anchoring to a concrete equipment pad.

B. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

C. Lifting Lugs: Equipment weighing over 100 pounds.

D. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications. Coat in accordance with Section 09900, Painting and Coating.

E. Provide 4-inch hand hole cleanout port, test ports, and drain connections for maintenance.

2.06 FACTORY FINISHING

A. Prepare, prime, and finish coat in accordance with Section 09900, Painting and Coating, System No. 9.

2.07 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect equipment for required construction and intended function.

B. Factory Tests and Adjustments: Test all equipment actually furnished.

C. Factory test report of functional test.

D. Functional Test: Perform manufacturer’s standard, test on equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s printed instructions.

B. Mount heat exchanger level on concrete equipment pad and grout bases with minimum of 1-inch thick grout.

C. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05500, Metal Fabrications.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09900, Painting and Coating, System No. 9.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each exchanger.

1. Alignment: Test complete assemblies for proper alignment and connection, leakage, and quiet operation.

B. Performance Test:

1. Conduct on each exchanger.
2. Test for a continuous 30-minute period on sludge and hot water channels without malfunction or leakage.
3. Test separately sludge and hot water channels by filling individual channel with 165 degrees F water and applying a pressure of 100 pounds per square inch gauge for a continuous 30-minute period.
4. Test for a continuous 30-minute period and assess actual amount of heat transferred under design parameters.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 2 person-days for performance testing and completion of Manufacturer's Certificate of Proper Installation.
   b. 1-person-day for facility startup.

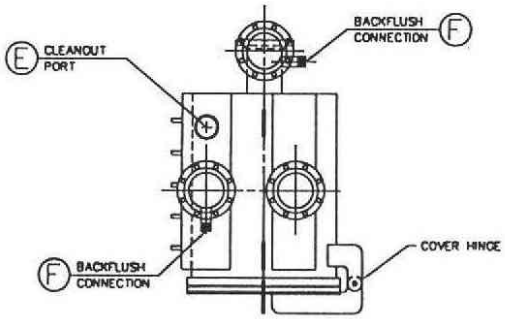
B. See Section 01640, Manufacturers' Services and Training, and Section 01756, Testing and Facility Startup.

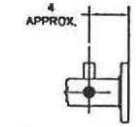
3.05 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

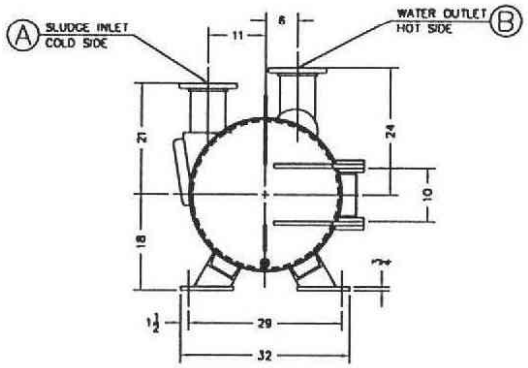
1. Existing Heat Exchanger Data Sheet.

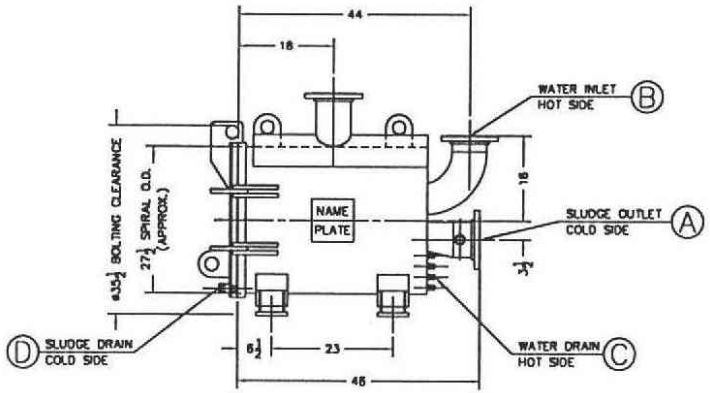
END OF SECTION





G TEST PORT DETAIL (2 ON EACH NOZZLE)





MODEL 36W-120A PERFORMANCE DATA		
	HOT SIDE	COLD SIDE
	WATER	3% SLUDGE
FLUID FLOW (GPM)	269	650
TEMP. IN/OUT (°F)	165/149.9	95/101.1
PRESSURE DROP (psi)	2.84	2.86
VELOCITY (Ft/S)	5.03	6.02
DENSITY (Lb/Ft^3)	61.01	62.4
SPECIFIC HEAT (BTU/Lb °F)	.998	1.0
THERMAL COND. (BTU/H Ft °F)	.382	0.36
VISCOSITY IN/OUT (cP)	.382/.429	.8
HEAT DUTY (BTU/H)	1,972,000	

WEIGHTS (APPROX)

EMPTY =	2300 lbs	FLOODED =	2925 lbs

PRESSURES

INNER CHANNEL (HOT SIDE)		OUTER CHANNEL (COLD SIDE)	
MAX. ALLOWABLE WORKING PRESS. =	50 psig	MAX. ALLOWABLE WORKING PRESS. =	50 psig
HYDROSTATIC TEST =	65 psig	HYDROSTATIC TEST =	65 psig

DESIGN TEMP

INNER CHANNEL (HOT SIDE)		OUTER CHANNEL (COLD SIDE)	
MIN =	20 °F	MIN =	20 °F
MAX =	200 °F	MAX =	200 °F

CHANNELS (Hot Side Welded Closed; Cold Side Open Both Ends)

INNER CHANNEL (HOT SIDE)		OUTER CHANNEL (COLD SIDE)	
SPACING =	1/2 in	SPACING =	1 in

SPIRAL

OUTER THICKNESS	MATERIAL
.25 THICK x 36 WIDE	SA-516, Gr. 70

NOTES:

1.) DESIGNED, CONSTRUCTED, AND "U" STAMPED IN ACCORDANCE WITH A.S.M.E. CODE SEC VIII-DIV. 1, 1998 EDITION, ADDENDA 1999.

2.) ALL DIMENSIONS ARE IN INCHES, UNLESS OTHERWISE NOTED.

3.) ALL HEADS ARE SA-516-70(N).

4.) GASKETS- KLINGER SIL C4401, NON-ASBESTOS, 1/8" THK x 31" NOM. DIA.

5.) HOOKBOLT ASSY, 20 PER COVER, 3/4" DIA. x 8" LG, SA-193, B7, ZINC PLATED.

6.) PAINT- AMERON AMERLOCK 400FD, COLOR: ALFA LAVAL BLUE, MANUFACTURER'S STANDARD.

7.) TOLERANCE ON ALL DIMENSIONS ±1/8", TOLERANCE ON ANGULAR DIMENSIONS ±1/2°, BOLT HOLES TO STRADDLE SHOWN CENTER LINES, ±1°.

8.) LOCATION OF NAMEPLATE IS MANUFACTURER'S OPTION.

9.) FOR WELD DETAILS SEE DRAWING NO. D-120.

NOZZLES A, B, E, & F ARE SA-106, Gr. B, SCH 40.
CONNECTIONS C, D, & G ARE SA-105.
FLANGES ARE SA-105.

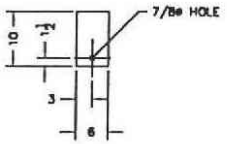
MARK	REQ'D	SIZE	RATING	FACING	REMARKS
G	8	3/4"	3000#	CPLG.	PLUGGED
F	2	2"	***	NPT	CAPPED
E	1	4"	***	NPT	CAPPED
D	1	3/4"	3000#	CPLG.	PLUGGED
C	4	3/8"	3000#	CPLG.	PLUGGED
B	2	6"	150#	SO-RF	
A	2	6"	150#	SO-RF	

NOZZLE SCHEDULE

TAG UNIT
20M10301 (MFG. #24133)
20M10302 (MFG. #24134)

CERTIFIED PRINT
APPROVED FOR FABRICATION OR ERECTION
BY: Steven Yssaraga DATE: 8/23/00

CAUTION:
UNIT MUST BE BOLTED DOWN WHILE OPENING



MOUNTING PAD DETAIL

DATE	SYM.	DESCRIPTION	BY	CHK	APP	DATE
8/23/00	1	REVISED DRAWING TO CERTIFIED	JR	SMY	SMY	8/23/00

REVIEW
QC
AI

Alfa Laval Thermal Inc.
300 CHESTNUT STREET
LYNDHURST, PA 17048-0010

Sloyden Construction, Inc.

218-13224

SLUDGE HEATER
(2) 120 SQ. FT. SPIRAL HEAT EXCHANGERS

JOB NO.	911364	DWG NO.	24133-24134
DRAWN BY	J. RITZMAN	DATE	8-14-00
CHK'D BY	SMY	SCALE	1 = 12
APP'D BY	SMY	SHEET	1 OF 1

DRAWING NO. 1H-24133-34

SECTION 11383
DIGESTER GAS SAFETY EQUIPMENT AND SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Class 25, Class 125, and Class 250).
   b. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   c. Boiler and Pressure Vessel Code (BPVC), Section VIII, Rules for Construction of Pressure Vessels.
2. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts, maximum).

1.02 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330, Submittal Procedures. In addition, the following specific information shall be provided:

1. Shop Drawings:
   a. Make, model, and weight of each equipment assembly.
   b. Manufacturer’s catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Detailed mechanical and electrical drawings showing equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment.
   d. Shop and Field Painting Systems Proposed: Include manufacturer’s descriptive technical catalog literature and specifications.
   e. Anchor bolt sizes based on results of anchorage design in accordance with Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer’s written/printed installation instructions.

4. Routine maintenance requirements prior to plant startup.
5. List of spare parts recommended by the manufacturer including part numbers, current price list, and contact for purchasing.
6. Operation and Maintenance Manual with Maintenance Summary Form in accordance with Section 01782, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01640, Manufacturer's Services and Training.

1.03 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Delivery: In accordance with Section 01600, Product Requirements.

1.04 SAFETY REQUIREMENTS

A. All equipment furnished shall be designed and manufactured with due regard to safety of operation, accessibility, and durability of parts, and shall comply with all applicable Occupational Health and Safety Act, federal, state, and local safety regulations.

PART 2 PRODUCTS

2.01 SERVICE CONDITIONS

A. Material Handled: Digester gas consisting of approximately 61 percent methane, 33 percent carbon dioxide, 5 percent water vapor, 1 percent nitrogen, and 100 parts to 1,000 parts per million (volume) hydrogen sulfide. Specific gravity ranges 0.75 to 0.95.

B. All flow devices shall be sized using the most conservative pressure and temperature ranges specified herein.

C. Atmospheric temperatures range from 10 degrees F to 110 degrees F.

D. Atmospheric pressure of 1 atm.

2.02 WASTE GAS BURNER REFURBISHING

A. General:

1. Refurbish existing waste gas burner as specified herein.
2. Recommission gas burner to demonstrate proper operation.

3. Capacity: 88,150 scfh digester gas at maximum pressure drop of 0.5-inch WC. Digester gas will have a minimum heat content of 550 Btu per cubic foot and will be saturated with water at 50 degrees F.
4. Size: 8 inches, with 1/2-inch pilot line.
5. Pilot Fuel: Natural gas.

B. Electronic Controller Replacement:

1. Replace the electronic controller inside the existing control panel.
2. Electronic Controller Part Number: P011-05-118-REPLACEMENT.

C. Ignition System Replacement:

1. Furnish with ignition and flame lead cable. Field mount control unit adjacent to burner pedestal in new explosion proof, NEMA 7 enclosure. Control unit and cable shall be suited for operation at ambient temperatures to 115 degrees F. Provide access to pilot burner so that it can be manually ignited.
2. Match existing equipment and recommission to demonstrate proper operation.
3. Venturi: 2-inch NPT, aspirating, to supply a combustible air/gas mixture to the continuous flame nozzle.
   a. Include a combustion chamber, spark plug, and flashback preventer.
   b. Furnish 1/2-inch NPT inlet connection.

D. Waste Gas Burner:

1. Refurbish Existing Waste Gas Burner:
   a. Strip existing paint coating.
   b. Surface prepare, prime, and finish paint in accordance with Section 09900, Painting and Coating, System No. 14.

E. Manufacturer: Varec.

2.03 MOISTURE AND SEDIMENT TRAPS

A. Quantity: One.

B. Features:

1. Materials: Stainless steel.
2. 10-inch flanged inlet, outlet, and inspection nozzles.
3. Flow Capacity: 45,000 scfh at 1/2-inch WC maximum pressure drop.

4. Storage Capacity: 6 gallons of accumulated sediment and 6 gallons of condensate, minimum per unit.
5. Provide access to interior of unit without requiring its removal from operating position.
6. 1-inch connection for drip traps and 2-inch drain connection.

C. Manufacturer and Product: Varec; Figure 233.

2.04 PRESSURE/VACUUM RELIEF VALVE WITH FLAME ARRESTOR

A. Pressure/Vacuum Relief Valve and Flame Arrestor: Separate units with valve factory mounted on top of arrestor.

B. Pressure/Vacuum Relief Valves:

1. Vacuum Relief Set Pressure: Minus 2-inch WCG.
2. Vacuum Relief Allowable Under Pressure: 2-inch WC. (100 percent of setpoint).
3. Pressure Relief Set Pressure: 16-inch WCG.
4. Pressure Relief Allowable Over Pressure: 1.6-inch WC (10 percent of setpoint).
5. Vacuum Relief Full Open Minimum Capacity: 120 actual cubic feet per minute.
6. Pressure Relief Full Open Minimum Capacity: 500 actual cubic feet per minute.
7. Size, Minimum: 8 inches.

C. Flame Arrestor:

1. Arrestor bank assembly shall be a separate unit, easily removable without disconnecting unit.
2. Flame arrestor net fee area through the bank assembly shall be not less than three times the corresponding size standard pipe. Entire bank assembly shall slide easily out of the arrestor housing to facilitate inspection and cleaning. Removing or replacing the bank assembly shall not require support for alignment and shall not place a strain on the connecting piping. Maintenance of the bank assembly shall not require removal of the valve for installation. Flame arrestor shall be self-draining.
3. Flame Arrestor Housing: Aluminum.
4. Bank Assembly: Aluminum.
5. Sheet Material: Type 316 stainless steel.
6. Additional Hardware: Stainless steel.

D. Provide “all weather” features to protect valve operation in temperatures ranging from minus 25 degrees F to 200 degrees F. Include the following:

1. Special antifreeze coating applied to seat ring tip.
2. Pallet periphery and stem.
3. Guide posts.

E. Insulation:

1. Insulating jackets with 1-inch thick, 6-pound density fiberglass insulating material and silicone impregnated woven glass cloth lining.
2. Through-cover quilting pins for firm support of insulation.
3. Attach insulation jackets to units with a combination of Velcro and cinch belts.
4. Provide a removable flap with Velcro to allow access to the removable cover and bank assembly without removing the entire insulation jacket.

F. Manufacturer and Product: Varec; Figure 5811B.

2.05 FLAME ARRESTOR AND THERMAL SHUT OFF VALVE ASSEMBLY

A. One 12-inch size, mounted on DC1 waste gas burner supply.

B. Assembly consisting of flat-on-bottom body flame arrestor and thermal shutoff valve.

C. Aluminum construction, Type 316 stainless steel flame arrestor sheets, and stainless steel hardware.

D. Manufacturer and Product: Varec; Figure 450.

2.06 BACK PRESSURE REGULATORS

A. Quantity: One, mounted on DC1 waste gas burner supply.

B. Size: 10 inches.

C. Capacity: 76,000 scfh at maximum 3-inch WC pressure rise above relief setting.

D. Setting: 15-inch WC, field adjustable 2-inch to 15-inch WC without disassembling diaphragm housing. Provide dial indicator showing pressure setting for spring type unit.

E. Manufacturer and Product: Varec; 386 Series.

2.07 EMERGENCY PRESSURE AND VACUUM RELIEF HATCH

A. Quantity: One.

B. Provide emergency pressure and vacuum relief hatch to protect against emergency overflow events such as digester rapid rise, tank foaming, excessive withdrawal, or pipe breakage. Hatch shall be hinged, weight type, and shall re-seat when system operating pressure is achieved. Spring type shall not be acceptable.

1. Vacuum Relief Set Pressure: Minus 3-inch WCG.
2. Vacuum Relief Allowable Under Pressure: 1-inch WCG.
3. Pressure Relief Set Pressure: 20-inch WCG.
4. Pressure Relief Allowable Over Pressure: 2-inch WC.
5. Vacuum Relief Full Open Minimum Capacity: 120 actual cubic feet per minute.
6. Pressure Relief Full Open Minimum Capacity: 500 actual cubic feet per minute.
7. Size: 24 inches.
8. Hinged Arm: Stainless steel.
9. Cover: Aluminum.
10. Base: Aluminum.
11. Gasket: Neoprene.
12. Drip Ring: Aluminum.
13. Pressure Diaphragm: PTFE.
14. Diaphragm Seat: Aluminum.
15. Vacuum Relief Valve: Aluminum with stainless steel internals.

C. Manufacturer and Product: Varec; 400W.

2.08 DIGESTER SAMPLING PORT COVERS

A. Sampling hatch shall be 8-inch diameter.

B. Provide hatch with integral inclined foot pedal to facilitate opening. Include handwheel to ensure a positive seal with locking capability.

C. Aluminum construction, synthetic rubber gasket Buna-N cover insert, nonsparking construction.

D. Manufacturer and Product: Varec; 42 Series.

2.09 FOAM SEPARATORS

A. Quantity: One.

B. Foam Separator Fabrication:

1. Stainless steel pipe and fittings as specified in Section 15200.08, Stainless Steel Pipe and Fittings—General Service.
2. Refer to the Drawings for fabrication details.

C. Gaskets: 1/8-inch neoprene full-face type.

D. Fasteners: Type 316 stainless steel.

E. Spray Nozzles: Stainless steel construction delivering 1.8 gpm in a full cone spray pattern at 40 pounds per square inch.

1. Manufacturer and Product: Spraying Systems Co.; Full Jet 3/8 GGD9.5.

2.10 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Anchor Bolts: Type 316 stainless steel sized by equipment manufacturer at least 1/2-inch in diameter, or as shown, and as specified in Section 05500, Metal Fabrications.

C. Equipment Identification Plates: Provide equipment nameplates in accordance with Section 10400, Signage.

2.11 FACTORY FINISHING

A. For carbon steel and cast-iron equipment and accessories, factory prepare, prime, and finish paint with manufacturer’s standard coating as specified in Section 09900, Painting and Coating, for exposed or high temperature surfaces.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer’s instructions.

B. Accurately place anchor bolts using templates furnished by manufacturer and in accordance with Section 05500, Metal Fabrications.

3.02 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each unit.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:
   a. 2 person-days for functional testing and completion of Manufacturer's Certificate of Proper Installation.
   b. 2 person-days for prestartup classroom or Site training.
   c. 1-person-day for facility startup.

END OF SECTION

SECTION 11385
DIGESTER MIXER

EQUIPMENT AND COMPONENT NUMBER(S)

725MX6503: Digester 3 Mixer.
725P9201: Digester 3 Mixer Oil Pump.

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. This section covers the work necessary to provide one mixer for Digester 3, including all appurtenances as specified herein.

1.02 GENERAL:

A. Related Sections: Section 16222, Low Voltage Motors Up to 500 Horsepower.

B. General Requirements: See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 01330, Submittal Procedures. In addition, the following specific information shall be provided:

1. Shop Drawings:
   a. Documentation of modifications to the manufacturer's standard design to meet the requirements specified in this section.
   b. Make, model, weight, and horsepower of each equipment assembly. Provide weights for mixer gearbox, motor, shaft, each impeller, and impeller hubs.
   c. Complete mixer and motor catalog information, descriptive literature, specifications, and identification of materials of construction for all components furnished.
   d. Mixer technical data including:
      1) Verification of specified materials and performance requirements.
      2) Calculations supporting all shaft and impeller design criteria (stresses and critical speeds) throughout entire liquid operating range and sludge characteristics sealed by a professional engineer registered in the State of Oregon.

3) Design rotating speed(s).
4) Bearing types and life calculations.
5) Pumping capacity and water horsepower or delivered horsepower.
6) Computational Fluid Dynamics (CFD) model showing mixer performance based on digester internal geometry and baffles.
7) Mounting requirements, torque and bending loads.
8) Drawing of mixer shaft seal through tank roof.
9) Mixer shaft and impeller disassembly procedures and access requirements.

e. Drive unit data including:
1) Verification of specified design, materials, and fabrication requirements.
2) Bearing life calculations.
3) Mounting requirements, including torque and forces to be supported by the structure.
4) Drive unit disassembly procedures and access requirements.
5) Description of lubrication system.

f. Detailed mechanical drawings showing the equipment dimensions, size, and locations of connections and weights of associated components.

g. Foundation drawings showing anchor bolt layouts and locations based on results of anchorage design in accordance with Section 01612, Anchorage and Bracing.

h. Anchor bolt sizes based on results of anchorage design in accordance with Section 01612, Anchorage and Bracing, signed and sealed by a civil or structural engineer registered in the State of Oregon.

i. Power and control wiring diagrams, including terminals and numbers.

j. Motor submittals as specified in Section 16222, Low Voltage Motors Up to 500 Horsepower.

k. Paint manufacturer’s technical data sheets for coating systems.

2. Anchorage and bracing design calculations and drawings in accordance with Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Factory test report.
2. Manufacturer’s installation instructions.
3. Welding procedures, welder certifications, and welding quality control for factory and field welding. Include fabrication procedures to relieve

internal stresses due to welding. Provide non-destructive testing of all welded joints (ultrasonic, radiographic, and dye penetrant testing).

4. Shipping, storage and protection, and handling instructions.
5. Routine maintenance requirements prior to startup.
6. List of spare parts recommended by the manufacturer including part numbers, current price list, and contact for purchasing.
7. Manufacturer's Certificate of Proper Installation in accordance with Section 01640, Manufacturer's Services and Training.
8. Operation and Maintenance Manual with Maintenance Summary Form in accordance with Section 01782, Operation and Maintenance Data.
9. Documentation of final fabricated or machined dimensions and tolerances of mixer shaft, impeller hubs, and impellers. The manufacturer is to provide a letter certifying that mixer shaft and appurtenances have been fabricated and machined to meet the manufacturer's specified dimensions and tolerances.[ADD. 3]

C. Submit all Drawings in U.S. units.

1.04 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Tools and Accessories: Provide one set of special tools and accessories required to install the mixer, assembly and disassemble the mixer, and to perform operation and maintenance activities on the mixer.

C. Lubricants: Provide all necessary greases and lubricants for the initial startup and replacement after initial commissioning period for all components specified in this section.

D. Delivery: In accordance with Section 01600, Product Requirements.

1.05 SAFETY REQUIREMENTS

A. All equipment furnished shall be designed and manufactured with due regard to safety of operation, accessibility, and durability of parts, and shall comply with all applicable Occupational Health and Safety Act, federal, state, and local safety regulations.

1.06 WARRANTY

A. The manufacturer shall warrant the equipment to be free of defects in design, material, and workmanship for a period of 1-year from the date of acceptance or 18 months after equipment delivery to the Project Site, whichever occurs first.

B. Provide an extended warranty on the mixer shaft for a period of 5 years from date of equipment delivery to the project site.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Materials, equipment, components, and accessories specified in this section shall be:

1. SPX Flow, Lightnin; Model 883QS60.

2.02 EQUIPMENT PERFORMANCE AND DESIGN REQUIREMENTS

A. Furnish each mixer to continuously and completely mix anaerobic wastewater sludge consisting of primary sludge, thickened waste activated sludge, scum, and including fats, oil, and greases for the tank geometry and baffles shown on the Drawings. Sludge characteristics include:

1. Solids Concentration:
   a. Average: 4 percent.
   b. Range: 2 percent to 6 percent.
2. Temperature Range: 90 degrees F to 145 degrees F.

B. Design Requirements:

1. Minimum Rated Pumping Capacity:
   a. Upper Impeller: 300,000 gpm axial flow.
   b. Lower Impeller: 115,000 gpm radial flow.
2. Maximum Motor Horsepower: 60.
3. Minimum Impeller Diameter/Tank Diameter Ratio:
   a. Upper Impeller: 0.18.
   b. Lower Impeller: 0.15.
4. Maximum Mixer Speed: 18 rpm.
5. Impeller Shaft Design: 40 percent of first lateral critical speed.
6. Design for effective sludge mixing for varying sludge levels as shown on the Drawings.

7. Design for stable operation for sludge levels varying from 10 feet above lower impeller up to maximum liquid level.
8. Design for manual control reversing motor for cleaning of debris from impellers. Reverse rotation to have minimum 1-minute delay after shutdown of forward rotation.
9. Tank Mixing Performance: Minimum mixing velocity of 0.1-foot per second over greater than 90 percent of the tank volume.
10. Environment for Mixer Equipment Outside of the Tank:
    a. Outdoors, with exposure to direct sun, rain, snow, sleet, and freezing rain.
    b. Temperature Range: 15 degrees F to 115 degrees F.
    c. Humidity Range: 35 percent to 100 percent.

2.03 EQUIPMENT AND MATERIALS

A. Furnish mixer assembly consisting of a heavy-duty speed reducer, electric motor connected through a flexible coupling, baseplate, agitator shaft, and mixing impellers.

B. Mixer Gear Drive:

1. Provide a mixer gear drive built in accordance with the current American Gear Manufacturers Association (AGMA) standards. Furnish AGMA calculated drive horsepower rating stamped on drive nameplate. Furnish drive housing of high-quality close-grained cast iron, or fabricated steel, stress relieved and reinforced, and with lifting lugs or holes.
2. Provide each unit with integral or a separate equipment support frame.
3. Provide gearing of all helical or a combination of helical and spiral bevel. Furnish gearing of AGMA Quality No. 10 or better per ANSI/AGMA 2000-A88.
4. Gearing shall be isolated from unbalanced hydraulic loading on the mixing impellers by means of separate agitator shaft bearings located above and below the main drive bearings. The agitator shaft shall pass through the drive's hollow quill drive shaft and connect to the drive shaft by means of a torsionally resilient flexible coupling.
5. Provide full load operating noise levels of the mixer drives meeting current Occupational Safety and Health Administration (OSHA) Occupational Noise Standards, and/or ANSI/AGMA 6025-D98, and not exceed 85 dBA at 3 feet from any part of the drive assembly.
6. Provide with minimum AGMA service factor of 2.0 based upon motor nameplate horsepower.

7. Output Shaft:
   a. Hollow quill design.
   b. Positive leakproof seal with drywell. Drywell shall be integral to the gear drive housing. Bolt-on drywell that requires a gasket will not be acceptable.
   c. Oversized for direct, rigid coupling to impeller shaft.
   d. Overhung design, no underwater steady bearings.
   e. Maximum stress 11,000 pounds per square inch at maximum load.
   f. Independent bearing support between output shaft and impeller shaft to isolate speed reducer from shock loads, impeller bending loads, and the weight of the impeller shaft.
   g. Torsionally resilient, flexible coupling between hollow output shaft and impeller shaft.

C. Bearings:

1. Provide drive bearings of the antifriction type, ball or roller bearings. Furnish all bearings within the drive, including output shaft bearings, having minimum AGMA Bf-10 life of 100,000 hours when operating at full motor nameplate horsepower at design speed.
2. Thrust Bearings: Independent, carry all shaft and impeller loads, plus a minimum allowance of 25 percent of weight of shaft plus impeller.
3. Locate all bearings above bottom of support platform.

D. Lubrication System:

1. Oil lubricated.
2. Positive lubrication of all gears and bearings.
3. Provide pumped oil system including gear-type oil pump, oil filter, and cooling system as required to maintain recommended oil temperature.
4. Oil filter shall be external and accessible without disassembly of speed reducer.
5. Provide oil filter differential pressure gauge.
6. Provide internal heater to prevent condensation and to maintain oil at minimum recommended operating temperature under minimum ambient temperature of plus 15 degrees F. Provide 115V ac, single-phase heater not to exceed 1,200 watts.
7. Sight glass and dipstick oil-level indicators.
8. Adequate separation between oil and grease lubricated parts.
9. Oil breather located above maximum possible oil foam level.
10. Oil flow or pressure sensor to sense loss of positive lubrication on oil lubricated parts to automatically shut off the mixer, single-pole, double-throw contact rated at amps at 120V ac, rated for Class 1, Division I, Group G.

11. Oil Drain:
    a. Extended design.
    b. Valved with quick disconnect.
    c. Located for maximum residual oil level of 1/4-inch in housing with gravity drainage.
    d. One 1-inch diameter by 8-foot long flexible hose with stainless steel braided sheath and appropriate couplings to oil drain disconnects and vent for connection to gravity drainage piping from gear box. Use oil-resistant materials.
    e. Drain piping to be Type 304 stainless steel.
12. Grease fittings protected by removable neoprene cover and accessible using a standard grease gun with special 90-degree couplers.
13. Greased bearing with seal to retain grease.
14. Oil Fill: Permanent funnel and valve conveniently located for filling from oil pump fill hose.

E. Electric Motors:

1. General: Explosion-proof, rated for Class 1, Division I, Group G, in accordance with NEMA MG-A and Section 16222, Low Voltage Motors Up to 500 Horsepower. Provide 120V ac single-phase motor space heater.
2. Mixer Motor Speed: 1,200 rpm maximum.
3. Lube Oil Pump Motor Speed: 1,800 rpm maximum.

F. Couplings:

1. Connect the lower mixer shaft to the upper, or drive output shaft, by means of a rigid flanged coupling, of either the welded or interference fit hub type. Provide mating coupling faces having a rabbeted male and female piloted connection for accurate concentricity, not requiring match marks for alignment. The rigid coupling material of construction must match that of the agitator shaft.
2. Rated for 200 percent of full torque and 150 percent of axial load.
3. Flexible coupling between motor and speed reducer with provisions for positive alignment.

G. Shafting:

1. All exposed rotating mixer shafts and rotating components shall be provided with a totally enclosed expanded stainless steel safety guard in conformance with OSHA requirements. Banded access openings with screwed covers shall be provided where required for access to lubrication fittings.

2. Shaft: Type 304L stainless steel, one-piece construction. Shaft comprised of shaft sections bolted together are not acceptable.
3. Design the impeller shaft such that the maximum stress does not exceed 8,000 pounds per square inch under maximum operating loads. Provide an overhung design. Use of submerged bearings is not permitted.
4. Lower shaft straightness, rigid coupling squareness, and output shaft accuracy shall limit the total indicated runout at the lower end of the shaft to a maximum of 1/8-inch for every 10 feet of overhang, as measured when turning over by hand.
5. Provide shaft that is safe for operation when liquid level passes through upper impeller while mixer is running.
6. Auxiliary support members or truss supports within the digester are not allowed.

H. Shaft Seal: Supply mixer shaft with a manometer type liquid seal for installation in the mounting deck as shown on the Drawings. Manometer seal shall be designed for 24-inch of water column digester gas pressure and shall be constructed of Type 316L stainless steel.

I. Impellers:

1. Each mixer shall be provided with Type 304 stainless steel bolted construction impellers. Provide nylon lock hex nuts and lock washers for all submerged thru-bolt connections. For thread blind or thru-hole bolted connections provide a Type 304 stainless steel lock plate with bendable tabs to prevent each bolt from backing out.
2. Impellers shall be axial and radial flow impellers.
3. Connect impellers to the agitator shaft with a hook key for maximum security. Provide a keyway to allow for vertical adjustment of the impeller(s) plus/minus 12 inches in 3-inch increments.
4. Mixer shaft and impellers must be able to be removed from the tank openings.
5. The maximum stress in any impeller component shall not exceed 11,000 psi under maximum operating loads.
6. Grind all impeller edges smooth and free of burrs.

J. Tank Mixing Efficiency:

1. CFD modeling and analysis with velocity and streamline plots shall be provided as part of the mixer system to determine mixing efficiency. Modelling shall be performed specifically for this Project; modeling performed for similar project shall not be acceptable. CFD modeling shall assume the following conditions:
   a. Begin in a completely unmixed state as defined by a velocity gradient of zero throughout the tank (day 0).
   b. Continuous sludge feed and withdrawal rates based on all of the inlet and outlet sludge rates specified above.
   c. 2.5 percent solids within the tank at start of mixing.
   d. Model shall run until full mixing is achieved, or for 8 hours, whichever is a longer period. Full mixing shall be defined as 90 percent of tank volume having velocity values greater than 0.1 feet per second.
   e. System shall be capable of holding a fully mixed condition indefinitely; however, model shall be run to show a projection of tank state at day 20.

2.04 ELECTRICAL COMPONENTS AND ACCESSORIES

A. General: Provide all necessary electrical components and wiring for a complete, functional system. Electrical components shall be provided in accordance with the requirements of Division 16, Electrical.

B. Electrical Raceways: All electrical wiring shall be installed in conduit meeting the requirements of Section 16130, Conduits. All raceways shall be installed in accordance with Section 16130, Conduits, and NFPA 70.

C. Motors: Provide squirrel-cage ac induction motors meeting the requirements of Section 16222, Low Voltage Motors Up to 500 Horsepower, and as specified herein.

2.05 ACCESSORIES

A. Lifting Lugs: Equipment and each component thereof weighing over 50 pounds shall be provided with lifting lugs for each handling.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 5/8-inch minimum diameter, and as specified in Section 05500, Metal Fabrications.

2.06 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Provide equipment nameplates in accordance with Section 10400, Signage.

2.07 FACTORY FINISHING

A. Motors and Gear Reducers: Prepare and coat in accordance with Section 09900, Painting and Coating, System No. 4.

B. Stainless steel components shall not be painted and shall be clean, free of iron deposits, and of uniform, mill-type finish. Surfaces with iron contamination shall be cleaned, descaled, and passivated per ASTM A380.

2.08 SOURCE QUALITY CONTROL

A. The Owner reserves the right to witness the tests specified herein and to inspect the fabrication procedures at any time during the fabrication stage(s) of the mixer shaft, assembly of the gearbox and associated equipment. Owner's travel expenses will be borne by the Owner.

B. Factory or Shop Inspections and Tests:

1. Submit welding procedures, welder certifications, and welding quality control for factory welding. Include fabrication procedures to relieve internal stresses due to welding. Provide non-destructive testing of all welded joints by ultrasonic, radiographic, and/or dye penetrant testing.
2. Each mixer shall be functionally tested at the factory for vibration and maximum shaft run out. Provide Engineer with certified test results.
3. For motor testing requirements, see Section 16222, Low Voltage Motors Up to 500 Horsepower.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units in accordance with manufacturer's recommendations. Install embeds into tank concrete roof coordinated with the mixer shaft seal configuration.

3.02 FIELD FINISHING

A. Touch up finish coat in accordance with Section 09900, Painting and Coating, System No. 4. Contractor shall repair and refinish painted surfaces as required.

B. Each equipment unit shall be leveled, aligned, and shimmed into position. When leveling the unit, use the machined surface of the output shaft. At a minimum, a level with an accuracy of 0.005 inches per foot shall be used to level the unit. The unit shall be leveled before the mixer shaft is connected to the output shaft. Shimming between machined surfaces will not be permitted.[ADD. 3]

3.03 FIELD QUALITY CONTROL

A. Provide the services of a qualified manufacturer's service representative to inspect, operate, test, and adjust the equipment after installation.

B. Functional Test:

1. Prior to startup, all equipment described herein shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory operation of all components by means of a function test.
2. Plant effluent water can be used as the mixed medium.
3. Each unit shall be submitted to complete normal start and stop cycles. The unit shall then be submitted to a 4-hour running test. All safety and protection devices shall be checked for satisfactory operation.
4. Check vibration. Resonance to be avoided and excessive vibration are grounds for rejection of equipment. Maximum acceptable peak-to-peak amplitude 5 mils as measured anywhere on machine during full-load operating conditions. Vibration measurement and analysis shall be performed by third party entity. Suggested service provider is OTS Precision Balancing, Wilsonville, OR.
5. Check for high bearing and oil temperatures.
6. Check for motor overload by taking amperage readings during starting and continuous operation.
7. Check impeller shaft for excessive deflection by hand-turn operation. Deflection shall not exceed 1/8-inch per 10-feet of shaft length.
8. As part of draining the digester of the test water, conduct a 12-hour mixer functional test to confirm mixer balance when the upper impeller transitions from submerged to un-submerged condition. Operate mixer continuously starting with a liquid level a minimum of 3 feet above the upper impeller. Complete test when liquid level has decreased lower than 10 feet above the lower impeller. Monitor and record vibration levels throughout test duration.

C. Submit the manufacturer's representative's signed report describing in detail the inspection, tests and adjustments made, quantitative results and suggestions for precautions to be taken to ensure proper maintenance. The report must verify that the equipment conforms to the requirements of the

Contract for the service intended and is ready for permanent operation. Provide copies of this report to be included in the installation, operation and maintenance manuals.

3.04 MANUFACTURER'S SERVICES

A. Provide Manufacturer's Representative in accordance with Section 01640, Manufacturers' Services and Training. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1-person-day for installation assistance and inspection.
2. 2 person-days for functional testing and completion of Manufacturer's Certificate of Proper Installation.
3. 2 person-days for prestartup classroom or Site training of Owner's personnel, specific sessions as outlined in Section 01640, Manufacturers' Services and Training.
4. 1-person-day for facility startup

END OF SECTION

SECTION 13217
THERMOPLASTIC LINER FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C1147, Standard Practice for Determining the Short Term Tensile Weld Strength of Chemical-Resistant Thermoplastics.
   b. D638, Standard Test Method for Tensile Properties of Plastics.
   c. D4787, Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
   d. D6693, Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

1.02 SUBMITTALS

A. Action Submittals:

1. Scaled Drawings showing surfaces in plan or elevation view for each structure to receive lining, with joints, penetrations, seams, attachments, and welds fully detailed.
2. Drawings shall include termination and configuration details for the following items:
   a. Wall corners, wall to roof inside corner, penetrating adhesive anchored bolt through liner, interface to roof hatch embedded frame, interface to penetrating pipe, damaged liner patch, and other typically encountered conditions for a lined tank.
3. Product Data: Manufacturer’s catalog for plastic lining system, including product data indicating physical and chemical resistance properties.
4. Pull test results on shop welded joints.

B. Informational Submittals: Manufacturer’s installation instructions with specific details modified and tailored to each structure and portion of structure to receive liner, including attachments to formwork.

1. Manufacturer’s installation instructions with specific details modified and tailored to each structure and portion of structure to receive liner, including attachments to formwork.

2. Letter from manufacturer stating that:
   a. Installer has notified manufacturer of proposed installation.
   b. Manufacturer agrees with the intended application.
   c. Installer is qualified to do the Work and meets the quality assurance minimum experience requirements.
3. Installer Qualifications:
   a. List of references substantiating experience. Include project names and locations, installation dates, contactable names of project staff from the Owner and Engineer, descriptions of products used, types of structures lined, and application procedures.
   b. Include list of technical personnel who will perform work on liner.
   c. Technician certification, indicating that each technician has completed required training for welding or hot air fusion, fabricating, and installing liner.
4. Manufacturer's Product Qualifications: List of references substantiating successful application and performance of the proposed products to similar exposure and process conditions. Include project names and locations, installation dates, contactable names of project staff from the Owner, Engineer, and Installer, descriptions of products used, and types of structures lined.
5. Independent, Third Party Inspector Qualifications: List of projects substantiating linings inspection experience with proposed products, substrates, and process conditions. Include project name and location, application dates, and contactable names of project staff from the Owner, Engineer, and Applicator.
6. Lining system manufacturer's representative statement of qualifications.
7. Manufacturer's Certificate of Proper Installation in accordance with Section 01640, Manufacturers' Services and Training.
8. Written test reports of each test and inspection, submitted on a weekly basis.

1.03 QUALITY ASSURANCE

A. Lining System Manufacturer: Successful use of proposed sheet material in similar installations to this Project for minimum period of 10 years.

B. Manufacturer's Representative: As specified in Section 01640, Manufacturers' Services and Training.

C. Lining System Installer: Recommended and certified by manufacturer to do the Work. Each person doing the Work must have a minimum 5 years' experience applying proposed products.

D. Independent, Third Party Inspector:

1. An independent, third party inspector shall be retained by the Owner.
2. The inspector shall be onsite for the full duration of all lining work, including, but not limited to, cutting, attachment to forms, welding, hot air fusing, concrete pouring, form removal, and quality control testing.
3. A minimum of 5 years inspecting specified products is required.

1.04 PREINSTALLATION MEETING

A. Prior to beginning lining Work, schedule a meeting and be prepared to discuss the following subjects, as a minimum:

1. Required schedule.
2. Sequence of critical path work items.
3. Use of Site, access, office and storage areas, security, and temporary facilities.
4. Major product delivery and priorities.
5. Safety plan.

B. Attendees shall include:

1. Owner’s representatives.
2. Contractor’s office representative and resident superintendent.
3. Subcontractors’ representatives whom Contractor may desire or may request to attend.
4. Installer’s office representative and resident superintendent.
5. Independent, third party inspector.
6. Design-Builder’s representatives.
7. Others as appropriate.

1.05 STORAGE

A. Store materials in a clean and dry area, outside of the elements. Prevent materials from being exposed to direct sunlight.

B. Maintain storage temperatures within the manufacturer’s requirements.

C. Follow manufacturer’s instructions.

1.06 SPECIAL GUARANTEE

A. Furnish extended guarantee or warranty. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of Work specified in this specification section found defective during a period of 2 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in Contract Documents.

1. 23-Month Warranty Period Inspection: Owner will conduct inspection of interior lined surfaces prior to the end of warranty period. Owner will notify Contractor in advance of inspection and Contractor may attend at its option. Owner will prepare list of lining defects and failures identified during inspection and transmit to Contractor. List shall serve as notice of repairs required under warranty.
2. Repairs:
    a. If repairs are required, requirements of Contract shall apply including, but not limited to, requirements to remove standing water and perform repair work.
    b. Repair defective linings using lining materials, equipment, and methods similar to those used in original work. Materials shall be of fresh manufacture and continuously stored per manufacturer's recommendations.
    c. Provide extended warranty of 1-year for repairs.
    d. Complete repairs within 30 calendar days of Warranty Period Inspection.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Lining system specified in this section shall be products of:

1. GSE Lining Technology, Inc., Houston, TX; GSE Studliner Lining Systems.
2. Atlas Minerals and Chemicals, Inc., Mertztown, PA; Anchor-Lok Lining Systems.

2.02 MATERIALS

A. In accordance with ASTM C1147.

B. Composition:

1. Sheet liner, joint, corner, and welding strips formed by combination of high density polyethylene (HDPE) resin, pigments, and plasticizers, specially compounded to remain flexible.
2. Not less than 99 percent by weight of resin used in formulation shall be thermal plastic resin.
3. Do not use copolymer resins.

C. Chemical Resistance: Lining system suitable for exposure to sewage sludge with pH of 4 to 8, hydrogen sulfide, ammonia, and dilute sulfuric acid at ambient temperatures.

D. Physical Properties:

1. Lining system including sheets, joint, corner and welding strips initially tested at 77 degrees F plus or minus 5 degrees F:
   a. Minimum Tensile Strength: 2,200 pounds per square inch in accordance with ASTM D638 Type IV or ASTM D6693.
   b. Minimum Elongation: 500 percent in accordance with ASTM D638 Type IV or ASTM D6693.
2. Liner Sheet: 3 millimeters thick with locking extensions of same material.

E. Furnish lining system free from cracks, cleavages, or other defects. Liner sheet shall be impact resistance, flexible, and capable of being repaired during life of structure.

2.03 ACCESSORIES

A. Sealant Adhesive: Nonflammable and as supplied by liner manufacturer.

2.04 FABRICATION

A. Shop Welded Joints:

1. Fuse together individual sections of liners; thickness, corrosion resistance, and impermeability of welds shall be same as specified for liner sheets.
2. Cracks and separations of welds not acceptable.

B. Basic Sheets:

1. Width: 59 inches to 96 inches, nominal.
2. Length Tolerance: Plus or minus 1/4-inch for each 100 inches.

2.05 SOURCE QUALITY CONTROL

A. Design-Builder may elect to visit the factory to witness the spark testing and tensile strength testing of the liner.

B. Factory Inspections: Inspect liner sheets for holes using electrical spark tester set at voltage recommended by the manufacturer. Repair holes found in liner sheets in shop and retest prior to shipment.

C. Factory Tests: Measure tensile strength across shop welded joints in accordance with ASTM D638 Type IV or ASTM D6693. Minimum tensile strength required is 2,200 pounds per square inch. Test temperature to be 77 degrees F plus or minus 5 degrees F. Measure minimum width and thickness of reduced welded section.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. In accordance with manufacturer’s written instructions.
2. Installation of lining system in cold weather, including preheating of sheets and welding of joints, shall be done in accordance with manufacturer’s instructions.
3. Do not apply hot compounds to lining.
4. Provide accessory strips and miscellaneous accessories for a complete liner system.
5. Protect installed lining from construction equipment and materials.

B. Application to Cast-in-Place Concrete Structures:

1. Closely fit and secure liner sheets to inner forms in accordance with manufacturer’s written instructions. Cut sheets to fit curved and warped surfaces using minimum number of separate pieces. Weld 2-inch wide welding strip on or hot air fuse back of butt joints to prevent wet concrete from flowing around edges.

2. Return lining minimum 3 inches at surfaces of contact between concrete structure and items not of concrete, for example, manhole frames, gate guides, or brick manholes, and clay or cast-iron pipes. Follow same procedure at joints where type of protective lining is changed or new work is built to join existing unlined concrete. Seal return liner at each return to item in contact with plastic-lined concrete.
3. Install liner continuous over expansion or control joints per approved Shop Drawings.
4. Join lining in accordance with manufacturer's instructions and to provide flexibility and excess material to allow for differential movement.

C. Protect lining from damage when removing forms. Do not use sharp instruments to pry forms from lined surfaces. Pull remaining nails from lining without tearing and clearly mark resulting holes. Mark areas of abrasion, damaged surfaces, and form tie holes before ties are broken off.

D. Patching:

1. Patch torn, cut, seriously abraded areas, nail, and tie holes in lining.
2. Fuse welding strip patches to liner over entire patch area.
3. Continuously seal around larger patches with welding strip fused to patch and sound lining surrounding damaged area.

3.02 TESTS AND INSPECTION

A. Prior to placement of concrete, Design-Builder, Independent third party inspector, and Manufacturer's Representative must inspect for proper installation and fitment.

B. Allow access to Design-Builder, Independent third party inspector, and Manufacturer's Representative prior to placement of concrete.

C. After placement of concrete and removal of forms, perform probing test along all welds to locate poor bonding between materials. Perform probing per the liner manufacturer's recommendations. Use a nondestructive probing apparatus, such as a putty knife with rounded edges.

D. After placement of concrete and removal of forms, test field joints and patches for holes using electrical spark tester per ASTM D4787 and the manufacturer's recommendation. Where conflicts exist, the more stringent requirements shall apply. Repair discontinuities and retest. A conductive underlayment is not required.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01640, Manufacturers' Services and Training, during installation of liner in formwork, to advise, assist, and observe.

B. Provide manufacturer's representative at Site to observe patching, field welding, field testing, and to certify proper installation.

END OF SECTION

SECTION 15060
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
3. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Building Code (IBC).
5. International Code Council (ICC).
6. International Mechanical Code (IMC).
7. Manufacturers' Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
   b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 12 inches and smaller. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. Calculations for each type of pipe support, attachment, and anchor.

3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Seismic anchorage and bracing Drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.
5. Support channel end caps.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Maintenance information on piping support system.

1.04 QUALIFICATIONS

A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a registered professional structural engineer in the state where the Work is to be installed.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 12 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Piping 12 Inches and Larger: Support systems have been designed for piping shown.
4. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Seismic loads in accordance with governing codes and as shown on the Structural General Drawings.
3. Wind loads in accordance with governing codes and as shown on the Structural General Drawings.

4. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.
   a. Ductile-iron Pipe 8 Inches and Under: Maximum span limited to that for standard weight steel pipe for water service.
   b. Ductile-iron Pipe 10 Inches and Larger: Maximum span limited to 20 feet.
5. Support Spacing for Schedule 40 and Schedule 80 Steel Pipe:

Nominal Pipe Diameter (inches)	Maximum Span (feet)
1/2	6
3/4 and 1	8
1-1/4 to 2-1/2	10
3	12

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

PART 2 PRODUCTS

2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.

C. Materials: In accordance with the table on Drawing 001-G-072, Electrical Area Classification and Materials of Construction.

2.02 HANGERS

A. Clevis: MSS SP 58, Type 1.

1. Anvil; Figure 260 for steel pipe and Figure 590 for ductile-iron pipe, sizes 1/2-inch through 30 inches.
2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2-inch through 16 inches.
3. B-Line; Figure B3100, sizes 1/2-inch through 30 inches.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6.

1. Anvil; Figure 104, sizes 3/4-inch through 8 inches.
2. B-Line; Figure B3171, sizes 3/4-inch through 8 inches.

C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43.

1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1-inch through 30 inches.
2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

D. Pipe Rollers and Supports: MSS SP 58, Type 44.

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty).

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable “J” hanger MSS SP 58, Type 5.

1. Anvil; Figure 67, sizes 1/2-inch through 8 inches.
2. B-Line; Figure B3690, sizes 1/2-inch through 8 inches.

C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4-inch through 8 inches.

D. Channel Type:

1. Unistrut.
2. Anvil; Power-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).

2.04 PIPE SADDLES

A. Provide 90-degree to120-degree pipe saddle for pipe 6 inches and larger with baseplates drilled for anchors bolts.

1. In accordance with Standard Detail 15501.
2. Sizes 20 inches though 60 inches, Piping Technology & Products, Inc.; Figure 2000.

B. Saddle Supports, Pedestal Type:

1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
2. Nonadjustable Saddle: MSS SP, Type 37 with U-bolt.
   a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 63C base.
   b. B-Line; Figure B3095, sizes 1-inch through 36 inches with B3088S base.
3. Adjustable Saddle: MSS SP 58, Type 38 without clamp.
   a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
   b. B-Line; Figure B3092, sizes 3/4-inch through 36 inches with Figure B3088S base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer’s allowable loads.

C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.
4. Aickinstrut (FRP System).
5. Enduro-Durostrut (FRP Systems).

2.06 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, Type 8.

1. Anvil; Figure 261, sizes 3/4-inch through 24 inches.
2. B-Line; Figure B3373, sizes 1/2-inch through 30 inches.

2.07 ELBOW AND FLANGE SUPPORTS

A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.

B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.

C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.08 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.09 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2-inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2-inch through 24 inches.

2.10 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.11 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturers:

1. Mason Industries.
2. B-Line.
3. Anvil.

2.12 ACCESSORIES

A. Anchor Bolts:

1. Size and Material: Sized by Contractor for required loads, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications.
2. Bolt Length (Extension Above Top of Nut):
   a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
   b. Maximum Length: No more than a full nut depth above top of nut.

B. Dielectric Barriers:

1. Plastic coated hangers, isolation cushion, or tape.
2. Manufacturer and Products:
   a. B-Line; B1999 Vibra Cushion.
   b. B-Line; Iso Pipe, Isolation Tape.

C. Insulation Shields:

1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
2. Manufacturers and Products:
   a. Anvil; Figure 167, sizes 1/2-inch through 24 inches.
   b. B-Line; Figure B3151, sizes 1/2-inch through 24 inches.

D. Welding Insulation Saddles:

1. Type: MSS SP 58, Type 39.
2. Manufacturers and Products:
   a. Anvil; Figure Series 160, sizes 1-inch through 36 inches.
   b. B-Line; Figure Series B3160, sizes 1/2-inch through 24 inches.

E. Plastic Pipe Support Channel:

1. Type: Continuous support for plastic pipe and to increase support spacing.
2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2-inch through 6 inches with Figure B3106 Vee bottom hanger.

F. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

G. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
3. Welded Beam Attachment: MSS SP 58, Type 22.
   a. Anvil; Figure 66.
   b. B-Line; Figure B3083.
4. U-Channel Concrete Inserts: As specified in Section 05500, Metal Fabrications.
5. Concrete Attachment Plates:
   a. Anvil; Figure 47, Figure 49, or Figure 52.
   b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

H. Support Channel end Caps: Provide white, neoprene strut channel end caps at all locations.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.

7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.
13. Install protective neoprene caps on the ends of all exposed support channels
14. Galvanized Surfaces: Re-coat all scratches, cuts, drilled holes in galvanized surfaces with CRC Zinc-It, “or-equal.”
15. Debur and break all sharp corners of pipe support systems.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
   b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
   b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3 inches.
   c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
   a. Saddle Supports:
      1) Pedestal Type, elbow and flange.
      2) Provide minimum 1-1/2-inch grout beneath baseplate.
   b. Floor Mounted Channel Supports:
      1) Use for pipe smaller than 3 inches running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
      2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
      3) Attach pipe to channel with clips or pipe clamps.
   c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.

4. Insulated Pipe:
   a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.
   b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
   c. Wall-mounted pipe clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

1. New Concrete Ceilings:
   a. Concrete inserts, concrete attachment plates, or concrete anchors as limited below:
      1) Single point attachment to ceiling allowed only for 3/4-inch rod and smaller (8-inch and smaller pipe).
      2) Where there is vibration or bending considerations, do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
2. Existing Concrete Ceilings:
   a. Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:
      1) Single point attachment to ceiling is allowed only for 3/4-inch rod and smaller (8-inch and smaller pipe).
      2) Where there is vibration or bending considerations do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
3. Steel Beams: I-beam clamp or welded attachments.
4. Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
5. Concrete Beams: Concrete inserts, or if inserts are not used attach to vertical surface similar to concrete wall. Do not drill into beam bottom.

D. Saddles for Steel or Concrete Pipe: Provide 90-degree to 120-degree pipe saddle for pipe sizes 6 inches and larger when installed on top of steel or concrete beam or structure, pipe rack, trapeze, or where similar concentrated point supports would be encountered.

E. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.

3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

F. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
3. Dielectric Barrier:
   a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
   b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09900, Painting and Coating.

B. Stainless Steel: All shop and field fabricated stainless steel parts shall be cleaned, descaled, and passivated in accordance with ASTM A380.

END OF SECTION

SECTION 15080
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
   c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   e. C534/C534M, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
   g. C552, Standard Specification for Cellular Glass Thermal Insulation.
   h. C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
   i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
   k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   l. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
3. International Code Council (ICC): International Energy Conservation Code (IECC).
4. UL.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s descriptive literature.

PART 2 PRODUCTS

2.01 PIPE AND FITTING INSULATION

A. Type 1—Elastomeric:

1. Material: Flexible elastomeric pipe insulation, closed-cell structure in accordance with ASTM C534/C534M.
2. Temperature Rating: Minus 297 degrees F to 220 degrees F.
3. Nominal Density: 3 pcf to 6 pcf.
4. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.25 Btu-in./hr-square foot degrees F at 75 degrees F per ASTM C177 or ASTM C518.
5. Maximum water vapor transmission of 0.06 perm-inch per ASTM E96/E96M, Procedure A.
6. Joints: Manufacturer’s adhesive.
7. Flame Spread Rating: Less than 25 per ASTM E84.
8. Smoke Developed Index: Less than 50 per ASTM E84.
9. Manufacturers and Products:
   a. Nomaco; K-Flex.
   b. Armacell; AP Armaflex.

B. Type 2—Fiberglass:

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
   a. Owens Corning Fiberglass; ASJ/SSL-11.
   b. John Manville; Micro-Lok with Jacket.

C. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 pounds per square inch per ASTM C165.
4. Temperature Rating: Minus 290 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96/E96M.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.
10. Follow manufacturer’s recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

D. Type 4—Removable Insulation Blankets:

1. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, and other in-line piping appurtenances and equipment requiring periodic servicing.
2. Size Limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3 inches with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.
3. Low temperature insulating blankets rated up to 800 degrees F:
   a. Use: For service temperatures up to 800 degrees F.
   b. Insulation: Fiberglass fiber, K-factor 0.27 at 75 degrees F.
   c. Cover: 17-ounce fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800 degrees F.
4. Cover Fasteners:
   a. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.
   b. Tie wire fasteners are not permitted.
5. Manufacturers and Products:
   a. Pittsburgh Corning; Temp-Mat.
   b. Accessible Products; Thermazip 2000 Jacket.
   c. Thermal Energy Products, Inc.; Energy Wrap.

2.02 ROOF DRAIN AND OVERFLOW DRAIN SUMP INSULATION

A. Type 1: 1-inch thick.

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 15060, Piping Support Systems.

B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.

C. Steel Pipe: Insulation saddle or high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield at support location. Extend insert beyond shield.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Color: PVC jacketing shall be color coded to match colors listed in Piping Schedule where suitable matching colors are available. If no suitable colors are available jacketing shall be white.
3. Flame Spread Rating: 25 per ASTM E84.
4. Smoke Developed Index: 50 per ASTM E84.
5. Manufacturers and Products:
    a. Knauf Insulation; Proto 1000.
    b. Johns Manville; Zeston 2000 or 300.
    c. Speedline; 25/50 Smoke-Safe.

B. Type F2—Paint:

1. Type 1 Insulation: Acrylic latex paint, white, and suitable for outdoor use.
    a. Manufacturer and Product: Armacell; WB Armaflex finish.
2. Type 2 Insulation: In accordance with Section 09900, Painting and Coating.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
   a. RPR Products; Insul-Mate.
   b. ITW, Pabco-Childers.

D. Type F4—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1-Foot Above Grade: 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, self-sealing manual pressure seals; Pittsburgh Corning Pittwrap SS.
2. Type 3 Insulation—Greater that 1-Foot Above Grade: 30-mil modified bituminous membrane with self-sealing manual pressure seals; Pittsburgh Corning Pittwrap CW30.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule as shown on the Drawings.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.

3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Removable sections shall be secured using hook and loop strips. Tie-wire is not permitted.
9. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Insulate valves and fittings smaller than 3 inches with sleeved or cut pieces of same material. Seal and tape joints.
2. Insulate valves and fittings larger than 3 inches with Type 4 removable insulation blankets.

E. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

F. Roof Drains: Insulate vertical drops from roof drains to horizontal pipe, exposed and concealed horizontal piping, and 2 feet down on vertical risers from horizontal pipe.

G. Roof Drains and Overflow Drains: Insulate entire pipe runs. Where roof and overflow drains exist through an exterior wall ensure annular space between pipes and walls are properly sealed prior to insulating.

H. Refrigerant piping insulation: Refer to Section 15905, HVAC Insulation.

I. Roof Drain and Overflow Drain Sumps: Insulate entire sumps.

J. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

K. Aluminum Jacket:

1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
4. Do not use screws or rivets to fasten fitting covers.
5. Install removable prefabricated aluminum covers on exterior flanges and unions.
6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.

C. Painting Piping Insulation (Exposed to View):

1. Aluminum or color coded PVC jacketing does not require painting.
2. If insulated piping system is indicated to be painted in Section 15200, Process Piping—General, piping shall receive the following:
   a. Prime coat in accordance with Section 09900, Painting and Coating.
   b. Finished insulation (and not pipe) shall be painted in accordance with Section 09900, Painting and Coating.

3.04 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Service and Insulation Thickness Table.

END OF SECTION

Service and Insulation Thickness				
Service Type	**Pipe Legend**	**Thickness**	**Fluid Temperature (deg F)**	**Remarks**
HG–Heating Systems (steam, condensate, and hot water)	HWR HWS NPW/H	Pipe Size: Insulation Thickness Inches 1/4–1.5: 1.5 >1.5: 2	150 to 250	
CW–Cold Water (non-potable water)	NPW COND	Pipe Size: Insulation Thickness Inches: <1–<1.5: 0.5 1.5–>8: 1	40 to 60	
HT–Piping requiring heat tracing.	NPW FF	Pipe Size: Insulation Thickness Inches:* 1/4–3: 1 3.5–10: 1.5 12–16: 2 18–24: 2.5	Various	Insulate and heat trace outside lines 1' above grade as shown on Piping Schedule, Drawing 001-G-086. Use Type 3 insulation from 1' above grade to frost depth.
CS—Cooling Systems	RL RF	Pipe Size: Insulation Thickness Inches: <1: 0.5 1–8: 1	>140	

*Use these fluid temperatures unless otherwise noted in the Piping Schedule.

Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20-mph wind with 10-percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 16055, Pipe Heat Tracing. 2012 IECC requires 1-inch minimum thickness.

Refer to the Piping Schedule on the Drawing 001-G-086 for Insulation Types and Finish Systems.

SECTION 15120
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. American Society of Mechanical Engineers (ASME).
   a. B15.1, Safety Standard for Mechanical Standard Transmission Apparatus.
   b. B40.100 Pressure Gauges and Gauge Instruments.
   c. B40.200, Thermometers, Direct Reading and Remote Reading.
   d. BPVC Section VIII, Rule for Construction of Pressure Vessels.
3. National Electrical Manufacturers Association (NEMA).
4. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01612, Anchorage and Bracing.
2. Provide for products specified, as follows:
   a. Identify as referenced in Contract Documents.
   b. Manufacturer’s name and model number.
   c. Descriptive specifications, literature and drawings.
   d. Dimensions and weights.
   e. Pump Curves:
      1) Performance Curves Indicating:
         a) Relationship of flow rate to static pressure for various pump speeds.
         b) Brake horsepower curves.
         c) Acceptable selection range.
         d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point.
   f. Capacities and ratings.
   g. Construction materials.
   h. Pump type, size, drive arrangement, and bearings.
   i. Impeller type, diameter.
   j. Motor data.
   k. Power and control wiring diagrams, including terminals and numbers.

l. Vibration isolation.
m. Factory finish system.
n. Color selection charts where applicable.

3. Where submitted equipment results in change to piping and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's installation instructions.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements.
5. Test reports.
6. Operation and Maintenance Data: As specified in Section 01782, Operation and Maintenance Data; including as-built version of equipment schedules.
7. Certification of concentration of glycol solution.

PART 2 PRODUCTS

2.01 GENERAL

A. Pump clearances and layout shown on the Drawings are based on the "A-List" make and model listed in Supplement Hydronic Pumps. If other pumps are provided, the contractor is responsible for coordinating layout and clearance requirements.

2.02 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Supplement Hydronic Pumps at the end of this section and the Valve Schedules on the Drawings.

2.03 EQUIPMENT

A. Pressure and Temperature Test Plug:

1. Brass body.
2. 1/4-inch NPT.
3. Suitable to receive standard 1/8-inch temperature or pressure test probes.
4. Removable threaded brass protective cap.

5. Dual Neoprene core rated for 200 degrees F.
6. Manufacturers and Products:
    a. Sisco; Model BNO.
    b. MG Piping Products; Model PT.
    c. Peterson Equipment Co.; Pete's Plugs.

B. Wye Strainers 2-Inch to 12-Inch Diameter (Hot Water Service):

1. Materials:
    a. Bodies: Cast iron or semi-steel.
    b. Ends: Flanged.
    c. Screens: Brass or Type 304 stainless steel.
2. Suitable for following minimum pressure conditions:
    a. Water, Oil, and Gas Service: 200 pounds per square inch gauge.
3. Perforated Screens:
    a. For hydronic service for sizes 2 inches to 3 inches, perforation shall be 0.045-inch.
    b. For hydronic service for sizes 4 inches to 12 inches, perforation shall be 0.125-inch.
    c. Active Screen Opening to Pipe Area Ratio: 2.8, minimum.
    d. Free Area: 37 percent minimum.
4. Y-Strainer shall be of the high-performance low pressure drop design with the following minimum CV values:
    a. 2-Inch Pipe: 120.
    b. 2-1/2-inch Pipe: 160.
    c. 3-Inch Pipe: 227.
    d. 4-Inch Pipe: 457.
    e. 5-Inch Pipe: 600.
    f. 6-Inch Pipe: 976.
    g. 8-Inch Pipe: 1,607.
    h. 10-Inch Pipe: 2,574.
    i. 12-Inch Pipe: 3,200.
5. LPD-Mag should be equipped with minimum 8,000 Gauss magnet(s).
6. Manufacturers and Products:
    a. One of the following "or-equal:"
        1) Metraflex, LPD-MAG.
        2) Armstrong International Inc.; Code A1.
        3) ITT/Hoffman; 460 Series.

C. Suction Diffuser:

1. Body: 175 pounds per square inch gauge working pressure, cast iron.
2. Inlet straightening vanes with length no less than 2-1/2 times pump suction diameter.

3. Stainless steel combination diffuser-strainer-orifice cylinder with total free area equal to or greater than five times the cross-sectional area of pump suction; designed to withstand pressure differential equal to pump shutoff head.
4. Disposable 16-mesh startup strainer.
5. Permanent magnet located in flow stream, removable for cleaning.
6. Adjustable foot support designed to carry weight of suction piping.
7. Blowdown tapping in bottom, gauge tapping in side.
8. Manufacturers and Products:
    a. ITT/Bell & Gossett; Suction Diffuser.
    b. Taco; SD.

D. Piping Flexible Connectors:

1. Spherical connector.
2. Twin sphere.
3. Precision molded of multiple layers of Kevlar cord and EPDM cover.
4. Rated 175 psi at 200 degrees F.
5. 2 Inches and Smaller: Threaded union end connections.
6. 2-1/2 Inches and Larger: Steel or cast-iron flanges.
7. Manufacturers and Products:
    a. Mason; Safeflex.
    b. Metraflex; Metrasphere.

E. Circulation Pumps, In-Line Mounted:

1. Centrifugal type, stainless steel 3/4-inch NPT flanges, designed for plumbing or open loop heating systems.
2. Motor Type: Electronically Commutated Permanent Magnet Motor.
3. Impeller: Impact Modified PPE.
4. Shaft and Bearings: Ceramic.
5. O-Ring: EDPM.
6. All metal wetted parts Type 316 stainless steel.
7. Rating: 145 pounds per square inch gauge working pressure.
8. Maximum Working Temperature: 230 degrees F.
9. Performance and Capacities: Refer to Equipment Schedule.
10. Manufacturers and Products:
    a. ITT/Bell & Gossett; Series ecocirc 20-18.
    b. Grundfos; Series UPS 26-99 SFC.

F. Hydronic Pumps, In-Line Mounted:

1. Centrifugal type.
2. Resiliently mounted horizontal or vertical motor, as scheduled.

3. Cast-iron pump casing fitted with ANSI 125 companion flanges for in-line mounting. The volute shall be designed with a base ring matching an ANSI 125 flange that can be used for pump support.
4. Gauge tappings.
5. Cast-iron construction.
6. Shaft Seal: Mechanical seal.
7. Rating: 175 pounds per square inch gauge working pressure.
8. Performance and Capacities: Refer to Equipment Schedule.
9. Manufacturers and Products: ITT/Bell & Gossett; Series e-80B.

G. Hydronic Pumps, Base Mounted:

1. Centrifugal type.
2. Flexible coupling drive.
3. Steel base mounted, with anchor bolts and template.
4. Horizontal end suction construction.
5. Casing: Class 30B cast iron.
6. Pump volute shall be of a cast iron design for heating systems rated for 175 pounds per square inch gauge with integral cast iron flanges drilled for ANSI 125 companion flanges NPT pipe. Volute shall include gauge ports at nozzles, and vent and drain ports.
7. Impeller: Grade CF8 cast Type 304 stainless steel.
8. Renewable bronze wear rings.
9. Pump Spacer Coupling: Rexnord Omega.
10. Mechanical shaft seal: Manufacturer’s standard with EPR elastomer, carbon rotating face, and tungsten carbide stationary face.
11. Oil-lubricated ball bearings.
12. Bearings and impeller removable without disturbing piping.
13. Bearing assembly interchangeable with several pump sizes.
14. Removable coupling shield compliant with ASME B15.1, Section 8.
15. Rating: 125 pounds per square inch gauge working pressure.
16. For pumps controlled through a variable speed drive, select pump with no natural frequency between 50 percent and 100 percent of operating range.
17. Performance and Capacities: Refer to Equipment Schedule.
18. Manufacturers and Products:
    a. ITT/Bell & Gossett; Series 1510, 6G and 8GB.
    b. Taco; Model FE.
    c. Paco; Type L.

2.04 MOTORS

A. General:

1. Pump motors shall comply with provisions of Section 16222, Low Voltage Motors Up to 500 Horsepower.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Provide inverter-duty motors for pumps specified for use with variable frequency drives.
4. Motors shall not operate into service factor.

B. Motor requirements as follows, unless designated otherwise on Equipment Schedule:

1. Horsepower, Voltage, and Phase: As scheduled.
2. Enclosure: As scheduled.
3. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
4. Winding Thermal Protection: None.
5. Space Heater: None.
6. Number of Speeds: Single.
7. Number of Windings: One.
8. Motor Efficiency: Energy efficient.
9. Shaft Type: Solid, carbon steel.
10. Oil-lubricated ball bearings.
11. Mounting: As required for pump arrangement.
12. Service Factor: 1.15.

2.05 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location with 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification and as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05500, Metal Fabrications.

2.06 FINISHES

A. Manufacturers’ standard.

PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Suction Diffusers: Provide 16-gauge bronze startup strainer. Remove startup strainer after system flush and prior to balancing.

B. In-Line Mounted Pumps: Support pumps separately from piping.

C. Base Mounted Pumps:

1. Install in accordance with manufacturer’s written instructions.
2. Concrete Bases:
   a. Mount pump and driver on concrete base.
   b. Base Size: In accordance with details shown on the Drawings.
   c. Anchor securely in place.
3. Leveling Pump Base:
   a. Level base using steel wedges (steel plates and steel shims).
   b. Wedge Taper: Maximum 1/4-inch per foot.
   c. Use double wedges to provide level bearing surface for pump and driver base.
   d. Secure each pair of wedges in their final positions with one tack weld on each side after leveling is complete.
   e. Prevent change of level or springing of baseplate when anchor bolts are tightened.
4. Pump Assembly Adjustments:
   a. Align, plumb, and level driving units with driven units and interconnecting shafts and couplings.
   b. Flexible couplings shall not compensate for misalignment.
   c. Eliminate strain from attaching piping to pumps.
   d. Correct pump or driver misalignment, noisy operation, or other signs of improper setting.
5. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation, as specified in Section 03600, Grouting.

3.02 ACCESS AND CLEARANCE CONSIDERATIONS

A. Obstructions: Drawings do not attempt to show exact details of piping. Anticipate and work around obstructions.

B. Cover piping installed across aisles or other main access walkways with a protective checkered plate steel ramp, pitched a maximum of 2:12 to allow safe wheeled or foot traffic, and paint with a prime coat and two finish coats of Safety Yellow. Support ramp from floor and do not rest ramp directly on pipe.

C. Install specialties with suitable access clearances for maintenance or removal of replaceable components. Provide necessary couplings or flanges to maintain or remove specialties without removing connecting appurtenances.

D. Do not install water or steam piping immediately over or within a 3-foot horizontal clearance of any electrical panel, motor starter, or environmental control panel (ECP). Where piping is located within these zones, install piping inside a PVC conduit or shield electrical device to protect it from direct water access.

E. Provide an alternate safe means of access where equipment requiring periodic maintenance cannot be reached by walkways because of substitution of equipment or interference with ductwork, piping, or other mechanical conflicts resulting from construction. These may include:

1. Overhead platform with stairway or ladder access and safety railings or handholds.
2. Walk-through duct plenums with hinged access doors.
3. Other means as necessary to meet OSHA standards for safe maintenance procedures.

3.03 CLEANING AND ADJUSTING

A. Cleanup:

1. Thoroughly clean parts of the installation and remove refuse material at completion of the Work.
2. Check belt-drive tensions and alignments.
3. Lubricate motors and bearings in accordance with manufacturer’s service manuals prior to equipment startup.

B. Repair Work:

1. Perform repair work of existing facilities affected by mechanical work performed under this section. Include such items as:
   a. Replacement of ceiling tiles or plaster removed or damaged for access to ceiling.
   b. Patching walls and ceilings for piping and ductwork penetrations.
   c. Repair of concrete or asphalt paving removed for pipe access.

d. Other repairs as a result of extension and remodeling of existing mechanical systems.

3.04 SUPPLEMENT

A. The supplement listed below following “End of Section,” is a part of this specification:

1. Hydronic Pumps Schedule.

END OF SECTION

HYDRONIC PUMPS

SYMBOL				725P6601	725P6602	725P6623	725P6624
PUMP NAME				PRIMARY HEAT LOOP PUMP 1	PRIMARY HEAT LOOP PUMP 2	BOILER 3 PUMP	BOILER 4 PUMP
SERVICE				HEATING WATER	HEATING WATER	HEATING WATER	HEATING WATER
TYPE				BASE MOUNTED END SUCTION	BASE MOUNTED END SUCTION	INLINE	INLINE
PUMP DATA	CAPACITY		GPM	1540	1540	251	251
	HEAD		FT H_20	35	35	10	10
	MAXIMUM POWER		BHP	18.1	18.1	2	2
	IMPELLER DIAMETER		IN	10.625	10.625	5.5	5.5
	FLUID	TYPE		WATER	WATER	WATER	WATER
		CONC.	%				
	MIN. EFF.		%	77.9	77.9	67.8	67.8
	NPSH		FT			2.5	2.5
MOTOR DATA	RATED POWER		HP	20	20	2	2
	SPEED		RPM	1180	1180	1200	1200
	VOLT			460	460	480	480
	PH			3	3	3	3
	ENCLOSURE			TEFC	TEFC	TEFC	TEFC
MAX WEIGHT	LBS			1256	1256		
MANUFACTURER				BELL & GOSSETT	BELL & GOSSETT	BELL & GOSSETT	BELL & GOSSETT
MODEL NO.				e-1510 8GB	e-1510 8GB	e-80 5X5X7B	e-80 5X5X7B
APPLICABLE REMARKS:				C	C	A	A

REMARKS:

A: MOTOR CONTROL: MAGNETIC MOTOR STARTER, INSTALLED IN DIV 16 MOTOR CONTROL CENTER (MCC)
B: MOTOR CONTROL: MAGNETIC MOTOR STARTER, WALL MOUNTED
C: MOTOR CONTROL: ADJUSTABLE FREQUENCY DRIVE, INSTALLED IN DIVISION 16 MCC
D: MOTOR CONTROL: ADJUSTABLE FREQUENCY DRIVE, WALL MOUNTED

HYDRONIC PUMPS

SYMBOL				715P6601	715P6602	725P6613	715P6501
PUMP NAME				SECONDARY HEAT LOOP CIRCULATION PUMP 1	SECONDARY HEAT LOOP CIRCULATION PUMP 2	SLUDGE HEAT EXCHANGER HOT WATER PUMP 3	RECIRCULATION PUMP
SERVICE				HEATING WATER	HEATING WATER	HEATING WATER	NPW/HR
TYPE				BASE MOUNTED END SUCTION	BASE MOUNTED END SUCTION	BASE MOUNTED END SUCTION	INLINE
PUMP DATA	CAPACITY		GPM	1100	1100	269	5
	HEAD		FT H_20	47	47	10	15
	MAXIMUM POWER		BHP	18	18	0.88	0.04
	IMPELLER DIAMETER		IN	11.875	11.875	5.75	STANDARD
	FLUID	TYPE		WATER	WATER	WATER	WATER
		CONC.	%				
	MIN. EFF.		%	85.4	85.4	75	45.2
	NPSH		FT				
MOTOR DATA	RATED POWER		HP	20	20	1	70 W
	SPEED		RPM	1180	1180	1150	4518
	VOLT			480	480	480	115
	PH			3	3	3	1
	ENCLOSURE			TEFC	TEFC	TEFC	TEFC
MAX WEIGHT	LBS			1061	1061	266	10
MANUFACTURER				BELL & GOSSETT	BELL & GOSSETT	BELL & GOSSETT	BELL & GOSSETT
MODEL NO.				e-1510 6G	e-1510 6G	e-1510 4AD	ECOCIRC 20-18
APPLICABLE REMARKS:				C	C	A	

REMARKS:

A: MOTOR CONTROL: MAGNETIC MOTOR STARTER, INSTALLED IN DIV 16 MOTOR CONTROL CENTER (MCC)
B: MOTOR CONTROL: MAGNETIC MOTOR STARTER, WALL MOUNTED
C: MOTOR CONTROL: ADJUSTABLE FREQUENCY DRIVE, INSTALLED IN DIVISION 16 MCC
D: MOTOR CONTROL: ADJUSTABLE FREQUENCY DRIVE, WALL MOUNTED

SECTION 15183
REFRIGERANT PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
3. American Society of Mechanical Engineers (ASME):
   a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   b. B31.5, Refrigeration Piping and Heat Transfer Components.
4. American Welding Society (AWS):
   a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. BRH, Brazing Handbook.
5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. National Electrical Manufacturers Association (NEMA).
7. UL.

1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National Recognized Testing Laboratory.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings in 1/4-inch scale for refrigerant piping showing pipe and tube sizes, flow capacities location, elevations, fittings, accessories, and piping connections.
2. Manufacturer’s data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.

B. Informational Submittals:

1. Welding certificates.
2. Field quality control; test report.
3. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data

1.04 QUALITY ASSURANCE

A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.

C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.

B. Store piping in clean and protected area with end caps in place.

PART 2 PRODUCTS

2.01 MATERIALS

A. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings, and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.

B. Piping, 3 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.

C. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

D. Pipe Insulation: Refer to Section 15905, HVAC Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

A. Brazing Materials:

1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
2. Comply with AWS A5.8M/A5.8 for brazing filler materials.

B. Refrigerant Specialties:

1. Refrigerant Suction Line Filter-Dryer:
   a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 pounds per square inch.
   d. Provide size recommended by refrigeration equipment manufacturer.
2. Refrigerant Liquid Line Dryer:
   a. Provide refrigerant liquid line filter-dryer for all units.
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 pounds per square inch.
   d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
   e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
   a. Shutoff Valves:
      1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 pounds per square inch working pressure.
      2) Maximum Opening Pressure: 0.5 pounds per square inch gauge.
      3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
   b. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
   a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 pounds per square inch working pressure.
   b. Provide valve only if recommended by air-conditioning equipment manufacturer.
   c. Manual Operator: Provide optional manual operator to open valve.

d. Manufacturers:
   1) Alco Controls Div.; Emerson Electric Co.
   2) Automatic Switch Co.
   3) Parker Hannifin Corp.

3. Thermostatic Expansion Valve:
   a. Body Bonnet and Seal Cap: Forged brass or steel.
   b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
   c. Capillary and Bulb: Copper tubing filled with refrigerant.
   d. Suction Temperature: 40 degrees F.
   e. End Connections: Socket or flare.
   f. Working Pressure: 700 psig.
   g. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
      3) Danfoss Group Global.
4. Safety Relief Valve:
   a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   b. Seat Disk: Polytetrafluoroethylene.
   c. Working Pressure: 500 pounds per square inch gauge.
   d. Operating Temperature: 240 degrees F, maximum.
   e. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
      3) Danfoss Group Global.

D. Refer to Section 15060, Piping Support Systems, for piping shields and piping support requirements.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM

A. Install piping products in accordance with manufacturer’s written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.

B. Install dryers on liquid and suction lines.

C. Refrigerant Piping:

1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.

3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
5. Run piping as shown on the Drawings, taking care to avoid interference with other piping, conduit, or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
6. Trapping of lines shall not be permitted, except where indicated.
7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install refrigerant piping in protective conduit where installed belowground.
12. Install accumulator in suction line near condensing unit.
13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
14. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.

D. Pipe Sleeves:

1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 1/4 inch between outside of pipe or insulation, and inside wall of sleeves.
3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
4. Extend sleeves for insulated pipes 1/2 inch from wall faces and caulk to sleeve on both sides.

5. Seal terminal ends of pipe insulation with mastic.
6. Extend sleeves for lines passing through floors 3 inches above finished floor slab and caulk to slab.

E. Braze cap (seal) ends of piping when not connected to mechanical equipment.

3.02 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.03 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS “Brazing Handbook” Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.

F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

3.04 PIPE HANGERS

A. Refer to Section 15060, Piping Support Systems, for piping shields and piping support requirements.

3.05 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer’s instructions where not otherwise indicated.

3.06 FIELD QUALITY CONTROL

A. General:

1. Notify Engineer at least 48 hours before testing is performed.
2. Furnish equipment required for tests.
3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 300 pounds per square inch gauge minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 600 pounds per square inch gauge minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-millimeter Hg absolute (29.88-inch Hg gauge).
2. Evacuate system with vacuum pump until temperature of 35 degrees F (2 degrees C) is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 2 pounds per square inch (15 kPa).
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

3.07 ADJUSTING

A. General:

1. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
2. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
3. Perform following adjustments according to manufacturer's written instructions before operating refrigeration system:
   a. Open shutoff valves in condenser water circuit.
   b. Verify compressor oil level is correct.
   c. Open compressor suction and discharge valves.
   d. Open refrigerant valves, except bypass valves that are used for other purposes.
   e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 15200
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 DEFINITIONS

A. Submerged or Wetted:

1. Zone below elevation of:
   a. Roof of digester, including structure pipe penetrations.
   b. Liquid surface or within 2 feet above top of liquid surface.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
3. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code.
4. Local plumbing code.
5. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Pipe Corrosion Protection: Product data.

4. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01600, Product Requirements.
   a. Pipe and fittings.
   b. Factory applied resins and coatings.
2. Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
3. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   c. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.
4. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
5. Nondestructive inspection and testing procedures.
6. Test logs.
7. Pipe coating applicator certification.
8. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.
9. CWI inspection records and NDE test records.
10. Component and attachment testing seismic certificate of compliance as required by Section 01451, Special Inspection, Observation, and Testing.
11. Torquing requirements and procedures, including torque values, for flanged piping assemblies.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. 10 years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.

d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
e. Verification Welding Inspector: AWS QC1 Certified.

2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. The presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.05 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01600, Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. As specified on Piping Data Sheet(s) located at the end of this section as Supplement and on Piping Schedule located on the Drawings.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.03 JOINTS

A. Grooved End System:

1. Rigid type.
2. Use of flexible grooved joints allowed where shown on the Drawings or with prior approval by Engineer.
3. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.
4. Shop finished with epoxy in accordance with AWWA C210.

B. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher-pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

D. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than:
   a. 3 degrees for sizes through 12 inches.
   b. 2 degrees for sizes 14 inches through 16 inches.
   c. 1.5 degrees for sizes 18 inches through 24 inches.
   d. 1 degree for sizes 30 inches through 48 inches.
4. UL and FM approved.
5. Manufacturers and Products:
   a. EBAA Iron, Inc.; Megalug.
   b. Romac Industries,; RomaGrip.
   c. “Or-equal.”

E. Flexible Mechanical Compression Joint Coupling:

1. Heavy duty, non-shear coupling meeting ASTM C1173.
2. Manufacturers:
   a. Fernco Joint Sealer Co.; The Hulk Coupling.
   b. "Or-equal."

F. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through-flanged connections consisting of the following:

1. Polyethylene stub end thermally butt-fused to end of pipe.
2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Use insulating flanges where shown.
3. Bolts and nuts of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard. Retorque nuts after 4 hours.
4. Gaskets as specified on Data Sheet.

2.04 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or "or-equal" will be allowed.

2.05 DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. System components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.

2.06 PIPE CORROSION PROTECTION

A. Coatings, Tape Coating System, Wax Tape System: See Section 09900, Painting and Coating, for details of coating requirements.

B. Heat Shrink Wrap:

1. Type: Cross-linked polyolefin wrap or sleeve with mastic sealant.
2. Manufacturer and Product: Raychem; WPCT, TPS (for line sizes up to 8.625 inches or DN200 outside diameter).

C. Polyethylene Encasement (Bagging):

1. Encasement Tube:
   a. V-Bio Enhanced Polyethylene Encasement:
      1) Field-installed.
      2) Encase pipe and fittings in polyethylene tubing as specified in AWWA C105.
      3) Three-layer co-extruded, linear low-density polyethylene wrap.
      4) 8 mils minimum wrap thickness.
      5) Inner surface of polyethylene wrap infused with anti-microbial biocide and corrosion inhibitor.
      6) Candidate Suppliers:
         a) V-Bio.
         b) "Or-equal."
2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.

D. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.3 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   b. Bolt insulating sleeves shall be provided full length between insulating washers.
   c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.
   d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
   e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.

4. Flange Insulating Kits:
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length NEMA LI-1, G-10 grade.
   c. Insulating Washers: NEMA LI-1, G-10 grade.
   d. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
      1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
      2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.
5. Manufacturers and Products:
   a. Dielectric Flanges and Unions:
      1) Lamons ISOTEK, Houston, TX; ISOGUARD.
      2) GPT, Houston, TX; LineBacker.
      3) Advance Products and Systems, Scott, LA; Trojan.
   b. Insulating Couplings:
      1) Dresser; STAB-39.
      2) Baker Coupling Company, Inc.; Series 216.

2.07 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

2.08 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer’s identification and pipe serial number.
3. Location number on laying Drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.09 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule located on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. See Piping Schedule located on the Drawings, and Section 09900, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer’s instructions, except for damaged glass-lined pipe that is to be promptly removed from site.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer’s instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast-iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but, if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer or grooved joint flange adapter manufacturer.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified in Piping Data Sheets.

E. Grooved-End Joints:

1. Piping shall be grooved in accordance with manufacturer’s latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer’s standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer’s latest published installation instructions.

F. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

G. Brazed Joints for Refrigerant Piping:

1. Braze copper piping with silver solder complying with AWS A5.8/A5.8M.
2. Construct joints according to AWS Brazing Handbook, Chapter Pipe and Tube.
3. Inside of tubing and fittings shall be free of flux.
4. Clean parts to be joined with emery cloth and keep hot until solder has penetrated the full depth of the fitting and extra flux has been expelled.
5. Cool joints in air and remove flame marks and traces of flux.
6. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel the air.
7. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

H. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 15205, Process Piping Specialties.

I. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

J. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.

d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

K. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 15060, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of

piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

3. From Adjacent Work: Minimum 1 inch(es) from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

G. Provide stainless steel bird screen on open pipe ends connected to process piping (such as, vent piping), unless otherwise indicated on the Drawings. Attach bird screen with ring flange, threaded connection or other applicable pipe fitting.

3.06 INSTALLATION—BURIED PIPE

A. Joints:

1. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 02320, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day’s work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths

will not accommodate horizontal or vertical curves in alignment, provide:
   a. Shorter pipe lengths.
   b. Special mitered joints.
   c. Standard or special fabricated bends.
10. After joint has been made, check pipe alignment and grade.
11. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
12. Prevent uplift and floating of pipe prior to backfilling.

C. CPVC, or HDPE Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, Except CPVC, or HDPE: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1-3/4 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

E. Marking Tape and Tracer Wire: Provide nondetectable marking tape and tracer wire for all buried piping per Section 02320, Trench Backfill.

3.07 INSTALLATION—CONCRETE ENCASED

A. Provide reinforced concrete pipe encasement where shown on the Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in these specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on the Drawings for encasement requirements.

B. Where concrete encased piping crosses structure expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.08 PIPE CORROSION PROTECTION

A. Pipe coating and corrosion protection requirements listed in order of governance:

1. Piping Schedule, located on the Drawings.
2. Section 15200, Process Piping—General.
3. Section 09900, Painting and Coating.

B. Ductile Iron Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating, and as shown in Piping Schedule located on the Drawings.
2. Buried: Asphalt (or bitumastic) and wrap with polyethylene encasement.
3. Submerged or Embedded: Coat with epoxy as specified in Section 09900, Painting and Coating. If in potable water service, use NSF 61 approved epoxy.

C. Carbon Steel Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating.
2. Submerged or Embedded: Coat with epoxy as specified in Section 09900, Painting and Coating. If in potable water service, use NSF 61 approved epoxy.

D. Copper Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating.

E. PVC and CPVC Pipe, Exposed: As specified in Section 09900, Painting and Coating.

F. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09900, Painting and Coating, as applicable to base metal material.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, grooved couplings, vent and drain valves, and fasteners.
2. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with high build epoxy or wax tape system as specified in Section 09900, Painting and Coating.
   b. Bolts, Nuts, and Similar Items: Coat with wax tape system.

c. Flexible Couplings, Grooved Couplings, and Similar Items: Coat with wax tape system.
d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with high build epoxy and wrap entire valve in polyethylene encasement.
e. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

G. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer's instructions.

H. Tape Coating System: As specified in Section 09900, Painting and Coating.

I. Wax Tape System: As specified in Section 09900, Painting and Coating.

J. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.

K. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Connections to existing metallic pipe.
   c. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
   b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
   c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.09 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.
3. Submerged Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with joint harness specified in Section 15205, Process Piping Specialties.
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

3.10 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 15205, Process Piping Specialties.

3.11 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.12 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.13 INSULATION

A. See Section 15080, Process Piping Insulation.

3.14 HEAT TRACING

A. See Section 16055, Pipe Heat Tracing.

3.15 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

B. As specified in Section 09900, Painting and Coating.

3.16 PIPE IDENTIFICATION

A. As specified in Section 10400, Signage, and Section 09900, Painting and Coating.

3.17 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 15955, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code ASME B31.3 for Normal Fluid Service 5 percent of circumferential butt welds shall be random radiographed.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.18 CLEANING

A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air, natural gas, dry chlorine gas or liquid, and instrument air lines with compressed air at 4,000 fpm; do not flush with water.

C. Immediately after cleaning dry chlorine gas or liquid, and service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.

D. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

E. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

F. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.19 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Data Sheets.

Number	Title
15200.01	Cement-Mortar, Glass-Lined, and Ceramic-Epoxy-Lined Ductile Iron Pipe and Fittings
15200.03	Carbon Steel Pipe and Fittings—General Service
15200.08	Stainless Steel Pipe and Fittings—General Service
15200.10	Polyvinyl Chloride (PVC) Pipe and Fittings
15200.11	Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings
15200.13	Copper and Copper Alloy Pipe, Tubing, and Fittings

Number	Title
15200.19	Polyethylene Pipe (PE) and Fittings – Natural Gas Service
15200.20	Stainless Steel Pipe and Fittings—Thin Wall
15200.24	Preinsulated CPVC Piping

END OF SECTION

SECTION 15200.01
CEMENT-MORTAR, GLASS-LINED, AND CERAMIC-EPOXY-LINED DUCTILE IRON PIPE AND FITTINGS

Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA C151/A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Buried Liquid Service Using Mechanical or Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 3 and Table 5 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4 with asphaltic seal coat. Use only for liquid service. Glass: ASTM B1000. Ceramic Epoxy: Pipe and fittings to be ceramic-epoxy lined shall not have been previously lined. Surface preparation shall be made to surfaces free of grease, oil, or other substance with abrasive blasting using clean sand or grit abrasive. Lining shall be done within 8 hours of surface preparation and surfaces shall be reblasted if rusting appears before lining. Line with a total dry film thickness of 40 mils of ceramic epoxy. Ceramic epoxy shall be amine-cured Novolac epoxy with 20 percent minimum volume ceramic quartz pigment, Protecto 401 by Induron Coating, "or-equal," for sewer service. Ceramapure by Induron Coating, "or-equal," for NSF 61 and potable water service. Lining shall be applied above 40 degrees F ambient temperature and shall not be applied to flange faces. Lining thickness shall be tested using a magnetic film thickness gauge. Lining integrity shall be tested on surfaces with a nondestructive, 2,500-volt dielectric resistance test.

SECTION 15200.01
CEMENT-MORTAR, GLASS-LINED, AND CERAMIC-EPOXY-LINED DUCTILE IRON PIPE AND FITTINGS

Item	Description
Fittings	Lined and coated same as pipe. Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron. Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2-degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Shop finished with epoxy in accordance with AWWA C210. Glass-lined Fitting: All Glass-lined fittings shall be long radius unless specifically shown otherwise. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.
Joints	Mechanical: 250 psi minimum working pressure. Proprietary Restrained: 250 psi minimum working pressure. American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex or HP Lok. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Dimensions per AWWA C110/A21.10 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed.

SECTION 15200.01
CEMENT-MORTAR, GLASS-LINED, AND CERAMIC-EPOXY-LINED DUCTILE IRON PIPE AND FITTINGS

Item	Description
	Branch connections 3 inches and smaller, except from glass-lined pipe, shall be made with service saddles as specified in Section 15205, Process Piping Specialties. Branch connections 3 inches and smaller from glass-lined pipe shall be made with glass-lined tee with a flanged branch for adapting to branch piping. Alternatively, holes 3 inches and smaller shall be located and prepared in the factory prior to application of glass lining. Field modifications to glass-lined pipe are not allowed.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Flanged: ASTM A307, Grade B carbon steel heavy hex head or stud bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M heavy hex head or stud bolts; ASTM A194/A194M, Grade 8M heavy hex nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations.

SECTION 15200.01 CEMENT-MORTAR, GLASS-LINED, AND CERAMIC-EPOXY-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Gaskets	General: Gaskets in contact with potable water shall be NSF ANSI 61 certified. Mechanical, and Proprietary Restrained Joints; Water and Sewage Service: Halogenated butyl or EPDM, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Mechanical, and Proprietary Restrained Joints; Hot Air Service: EPDM or Viton, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: Full face, 1/8-inch thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D1330. Blind flanges shall be epoxy-lined in accordance with the system specified above. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer’s standard.

END OF SECTION

SECTION 15200.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Pipe	All	Black carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW. Threaded, butt-welded, and flanged joints.
	Threaded:	
	1-1/2" & smaller	Standard weight.
	Welded:	
	2" thru 10"	Standard weight.
	12" thru 16"	Standard weight.
	18" thru 24"	Standard weight.
Joints	1-1/2" & smaller	Threaded or flanged at valves and equipment end meeting the requirements of AWWA C606.
	2" & larger	Butt-welded or flanged at valves and equipment meeting the requirements of AWWA C606.
Fittings	1-1/2" & smaller	Threaded: 150-pound or 300-pound malleable iron, ASTM A197/A197M or ASTM A47/A47M, dimensions in accordance with ASME B16.3. Fire sprinkler fittings to be UL listed.
	2" & larger	Butt Welded: Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.
Branch Connections	1-1/2" & smaller	For Threaded Pipe: Threaded, straight, or reducing tees in conformance with Fittings specified above. For welded pipe, use threadolet.
	2" & larger	Butt-welding tee in conformance with Fittings specified above.

SECTION 15200.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Flanges	1-1/2" & smaller	Forged carbon steel, ASTM A105/A105M, ASME B16.5, Class 150 socket-weld or threaded, raised face. When mating flange is flat face, provide flat face.
	2" & larger	Butt-Welded Systems Standard Flange (RFWN): Forged carbon steel, ASTM A105/A105M, ASME B16.5, Class 150 slip-on or welding neck, raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside. Butt-Welded Systems Standard Flange (FFWN): Forged carbon steel, ASTM A105/A105M, ASME B16.5, Class 150 slip-on or welding neck, flat face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside. Use when mating flange is plastic. Butt-Welded Systems Blind Flange: Forged carbon steel, ASTM A105/A105M, ASME B16.5, Class 150 or Class 300, facing to match mating flange. Cast Iron Mating Flange: AWWA C207, Class D or Class E, to mate with ASME B16.1, Class 125 cast-iron flange. AWWA C207 Class F or ASTM A105/A105M, ASME B16.5, Class 300 flat face to mate with ASME B16.1, Class 250 cast-iron flange.
Unions	1-1/2" & smaller	Threaded malleable iron, ASTM A197/A197 or ASTM A47/A47M, 150-pound or 300-pound WOG, meeting the requirements of ASME B16.3.
Couplings	2" & larger	Screwed End: Malleable iron, ASTM A197/A197M or ASTM A47/A47M.

SECTION 15200.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Bolting	All	Flanges: Carbon steel ASTM A307, Grade B heavy hex or stud bolts; ASTM A563, Grade A heavy hex head nuts. Torque bolts per gasket manufacturer recommendations. When mating flange on equipment is cast iron or plastic, provide ASTM A307, Grade B hex head or stud bolts; ASTM A563, Grade A heavy hex nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations.
Gaskets	All flanges	Water, Steam, and Air Services: Gasket, inorganic aramid fiber with nitrile binder, CL150, 1/8-inch thick, Shore A 80 Durometer, ASME B16.21 and ASME B16.5, ASTM D1330, NSF 61. Use only with raised face flanges. Use full-face or ring type gasket for raised-face flange. Fuel Gas Service: Full face, 1/8-inch thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated 250 degrees F continuous and conforming to ASME B16.21, ASTM D1330, Steam Grade. Use only with flat face flanges. Mating Flange: Cast iron or plastic. Full face, 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D1330. NSF 61 approved for potable water service. Insulating Gasket: ASME B16.21 and ASME 16.5, fabric reinforced phenolic neoprene faced gasket, sleeves, washers, CL150, 1/8-inch thick, 175 degrees F Step-Ko Type E DW, “or-equal.”

SECTION 15200.03
CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Thread Lubricant	1-1/2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. Fuel Gas Service: Yellow Teflon tape designed for fuel gas service, Air Force A-A-58092, AA Thread Seal Tape, Inc.

END OF SECTION

SECTION 15200.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Pipe	2-1/2" & smaller	Buttwelded Pipe, Schedule 40S: ASTM A312/A312M, Grade TP316/316L dual marked, seamless, pickled and passivated.
		Threaded Pipe, Schedule 80S: ASTM A312/A312M, Grade TP316/316L dual marked, seamless, pickled and passivated.
	3" thru 24"	Schedule 10S: ASTM A312/A312M, Grade TP316/316L, dual marked, seamless or welded pickled and passivated.
	30" & larger	AWWA C220, ASTM A240/A240M TP316/316L dual marked, wall thickness as shown on the Drawings.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment.
Fittings	1-1/2" & smaller	Threaded: Forged ASTM A182/A182M, Grade F316, conforming to MSS SP-114, Class 1000.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316/316L-S dual marked, conforming to ASME B16.9, annealed, pickled, and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" thru 24"	Butt-Welded: ASTM A403/A403M, Grade WP316/316L dual marked, conforming to ASME 16.9, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.

SECTION 15200.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
	30" & larger	AWWA C208, ASTM A240/A240M TP316/316L dual marked, wall thickness as shown on the Drawings, wall thickness to match adjoining pipe, long radius elbows, unless shown otherwise.
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Flanges	All	Stainless Steel: AWWA C228, Class SD, Type 316/316L. ASTM A182/A182M, Grade F316/316L, ASME B16.5, Class 150, flat face, weld neck, threaded, blind, or slip-on. Weld slip-on flanges inside and outside. Weld neck bore to match internal pipe diameter.
Unions	2" & smaller	Threaded Forged: ASTM A182/A182M, Grade F316, CL 3000, integral ground seats, AAR design meeting the requirements of MSS SP-83.
Bolting	All	Flanges: AWWA C228, Type 316 stainless steel, ASTM A193/A193M Grade B8M, Class 2 heavy hex head or stud bolts, ASTM A194/A194M, Grade 8M heavy hex head nuts. Torque bolts per gasket manufacturer recommendations. Anywhere mating flange on equipment is cast iron or plastic: Carbon steel ASTM A307, Grade B hex head or stud bolts, ASTM A563, Grade A hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendation.

SECTION 15200.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Gaskets	All Flanges	Flanged, Water, Hot Air, Fuel Gas and Sewage Services: Full face, 1/8-inch thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade.
Thread Lubricant (fittings)	1 1/2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. Fuel Gas Service: Yellow Teflon tape designed for fuel gas service, Air Force A-A-58092, AA Thread Seal Tape, Inc.

END OF SECTION

SECTION 15200.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454 conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M heavy hex head or stud bolts, ASTM A194/A194M, Grade 8M heavy hex head nuts and ASTM F436, Type 3 alloy washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations. With Raised Face Mating Flange: Carbon steel ASTM A307, Grade B heavy hex head or stud bolts, ASTM A563, Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations.

SECTION 15200.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

Item	Size	Description
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer. Solvent weld cement for PVC pipe joints in nonpotable water service shall be free of silica filler and shall be certified by the manufacturer to be suitable for the intended service, IPS Weld-On 711, “or-equal.” Solvent weld cement for PVC pipe joints in chemical service shall be free of silica filler and shall be certified by the manufacturer to be suitable for the intended service, IPS Weld-On 724, “or-equal.” Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

SECTION 15200.11 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
Pipe	All	Schedule 80 CPVC: Type IV, Grade I or Class 23447-B conforming to ASTM D1784 and ASTM F441. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded nipples shall be Schedule 80.
Fittings	All	Schedule to Match Pipe Above: Conforming to the requirements of ASTM F439 for socket weld type and Schedule 80 ASTM F437 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub Type CPVC flat face flange in accordance with Fittings above; ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Raised Face Mating Flange: Carbon steel ASTM A307m Grade B square head bolts, ASTM A563m Grade A heavy hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.

SECTION 15200.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

Item	Size	Description
Solvent Cement	All	All socket type joints shall be made employing primer and solvent cements that meet or exceed the requirements of ASTM F493 and primers that meet or exceed the requirements of ASTM F656 and as recommended by the pipe and fitting manufacturer. Solvent weld cement for PVC pipe joints in chemical service shall be free of silica filler and shall be certified by the manufacturer to be suitable for the intended service, IPS Weld-On 724, "or-equal." Certification shall be submitted. Solvent cement and primer shall be listed by NSF for use with potable water.
Thread Lubricant	All	Teflon tape.

END OF SECTION

SECTION 15200.13
COPPER AND COPPER ALLOY PIPE, TUBING, AND FITTINGS

Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	Seamless, conforming to ASTM B88 as follows: Water (buried) .....Type K, soft or hard temper Water (exposed) .....Type L, hard drawn Refrigerant Service.....Refer to Section 15183, Refrigerant Piping
Fittings	For Water and Refrigerant Service: ASTM B75/B75M commercially pure wrought copper, socket joint, dimensions conforming to ASME B16.22. For Exposed Water Service: Copper cold press connections compatible with ASTM B88 tubing and conforming to IAPMO PS117.
Flanges	Class 150, ASTM B75/B75M commercially pure wrought copper, socket joint, ASME B16.24 standard.
Bolting	ASTM A307, carbon steel, Grade A hex head bolts, ASTM A563, Grade A hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	1/16-inch thick nonasbestos compression type, full face, Cranite, John Manville.
Solder	Joints 2-1/2-Inch and Smaller: Wire solder (95 percent tin), conforming to ASTM B32 Alloy, Grade Sn95. Do not use cored solder. Joints Larger Than 2-1/2-Inch: Wire solder, melt range approximately 440 degrees F to 660 degrees F, conforming to ASTM B32 Alloy Grade HB or Grade HN. Do not use cored solder.

END OF SECTION

SECTION 15200.19
POLYETHYLENE (PE) PIPE AND FITTINGS—
NATURAL GAS SERVICE

Item	Size	Description
General	All	Pipe lengths, fittings, and flanged connections to be joined by thermal butt-fusion; shall be of the same type, grade, and class of polyethylene compound and supplied from the same raw material supplier. Pipe tubing and fittings manufactured in accordance with ASTM D2513.
Pipe	1/2" to 12"	ASTM D2513 medium-density polyethylene, maximum allowable hoop stress 1,250 psi at 73.4 degrees F. Polyethylene Resins: Conform to Type PE 2406/2708 or better. Pipe wall thickness shall reflect the required SDR* and diameter, as shown in Table 8, ASTM F714. Design Stress Rating: ASTM F1924, 1,250 psi hydrostatic design basis (HDB). Pressure Rating (psi) at 100 degrees F — SDR* 100 — 7.0 100 — 7.3 100 — 9.0 97 — 9.3 80 — 11.0 64 — 13.5 Note: Installed outdoors and underground only. Operating pressure for natural gas piping shall be limited to 100 psig or less per 2009 IFGC. Identification: Pipe and fittings shall be yellow in color and shall be marked “ASTM D2513”. *SDR: standard dimension ratio = OD/thickness
Fittings	4" & smaller	Molded Fittings: Conform to PE 2406/2708. Socket Fusion Fittings: Meet requirements of ASTM D2683. Butt Fusion Fittings: Meet requirements of ASTM D3261.

SECTION 15200.19 POLYETHYLENE (PE) PIPE AND FITTINGS— NATURAL GAS SERVICE		
Item	**Size**	**Description**
Flanges	All	Flanges not permitted underground. Aboveground, flanges and bolting shall be part of approved, listed transition fitting.
Risers and Transitions		Anodeless, pre-bent, single-seal riser with 6 foot long polyethylene pigtail and fusion bonded epoxy coating conforming to ASTM F1973.
Manufacturers and Product		Pipe: JM Eagle UAC 2000 MDPE yellow gas pipe; Driscoplex 6500 series. Risers and Transitions: George Fisher Central Plastics.

END OF SECTION

SECTION 15200.20
STAINLESS STEEL PIPE AND FITTINGS—THIN WALL

Item	Size	Description
Pipe	2" & smaller	Buttwelded Pipe, Schedule 5S: ASTM A312/A312M, Type 316L, seamless, pickled, and passivated. Schedule 5S pipe shall be approved by fitting manufacturer for service.
	1-1/2" thru 12"	Buttwelded Pipe, Schedule 5S: ASTM A778, “as-welded” grade, Type 316L, pickled, and passivated.
	14" & larger	Schedule 10S Wedge Groove: ASTM A778, “as-welded” grade, Type 316L, pickled, and passivated.
Joints	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316/316L-S dual marked, conforming to ASME B16.9, annealed, pickled, and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" thru 24"	Butt-Welded: ASTM A403/A403M, Grade WP316/316L dual marked, conforming to ASME 16.9, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	30" & larger	AWWA C208, ASTM A240/A240M, TP316/316L dual marked, wall thickness as shown on the Drawings, wall thickness to match adjoining pipe, long radius elbows, unless shown otherwise.

SECTION 15200.20
STAINLESS STEEL PIPE AND FITTINGS—THIN WALL

Item	Size	Description
Fittings	1-1/2" & smaller	Threaded: Forged ASTM A182/A182M, Grade F316, conforming to MSS SP-114 Class 1000.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316/316L-S dual marked, conforming to ASME B16.9, annealed, pickled, and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" thru 24"	Butt-Welded: ASTM A403/A403M, Grade WP316/316L dual marked, conforming to ASME 16.9, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
Flanges	All	Van Stone type with stainless-steel, butt-welded stub ends with raised face, lapped joint, ANSI Class 150, ASTM A240/A240M, Type 316L "as-welded grade," conforming to ASME B16.9, wall thickness same as pipe. Backing flange same material as pipe. Cast stainless (300 psi maximum) roll groove adaptor fitting CF8M, ASTM A351/A351M, ASTM A743/A743M, ASTM A744/A744M.
Bolting/Nuts	Flanges	Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTM A194/A194M, Grade 8M hex head nuts.
	Couplings	Grade "T" Nitrile: Temperature range minus 20 degrees F to plus 180 degrees F/minus 29 degrees C to plus 82 degrees C. Petroleum products, air with oil vapors, vegetable, and mineral oils.

END OF SECTION

SECTION 15200.24 PREINSULATED CPVC PIPING SYSTEM		
Item	**Size**	**Description**
Pipe	All	CPVC per Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet.
Joints	All	Solvent socket weld per Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet. Flanged or threaded only as applicable for attaching valves and special fittings/equipment.
Fittings	All	Solvent socket-welded. See Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet. Fittings shall be fully restrained (socket welded) and insulated. Provide bolster pads/expansion pillows as required at elbows to provide for thermal expansion/contraction.
Flanges	All	See Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet. Only as applicable for attaching valves and special fittings/ equipment.
Bolting	All	See Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet.
Gaskets	All	See Section 15200.11, Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet.
Thread Lubricant	All	Teflon tape.
Insulation	All	Polyurethane, rigid 90 percent to 95 percent closed cell foam with thermal conductivity of 0.16 (Btu) (in)/(hr) (sq-ft) (deg F) at 75 degrees F. Insulation Thickness: 2-inch minimum.
Operating Temp	All	125 degrees F.
Test Pressure	All	100 psig.
Outer Jacket	All	High-density polyethylene (HDPE).
End Seal/Closure Sleeve	All	High-density polyethylene (HDPE) same as jacket.

SECTION 15200.24 PREINSULATED CPVC PIPING SYSTEM		
Item	**Size**	**Description**
Manufacturers and Products	All	1. Thermacor Process Inc.; Chill-Therm. 2. Perma-Pipe.; XTRU-THERM. 3. Rovanco Corp.; CPVC system, HDPE jacket. 4. Thermal Pipe Systems; Kook-Kore.

END OF SECTION

SECTION 15202
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.
   f. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   g. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
   h. C542, Electric Motor Actuators for Valves and Slide Gates.
   i. C550, Protective Interior Coatings for Valves and Hydrants.
   j. C606, Grooved and Shouldered Joints.
   k. C800, Underground Service Line Valves and Fittings.
6. ASTM International (ASTM):
   a. A276, Standard Specification for Stainless Steel Bars and Shapes.
   b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
e. B61, Standard Specification for Steam or Valve Bronze Castings.
f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
    a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
    c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
    d. SP-88, Diaphragm Valves.
    e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
14. NSF International (NSF):

a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

15. UL.
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Sizing calculations for open-close/throttle and modulating valves.
   d. Anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01640, Manufacturer’s Services and Training, for:
   a. Electric actuators; full compliance with AWWA C542.
   b. Butterfly valves; full compliance with AWWA C504.
3. Component and attachment testing seismic certificate of compliance as required by Section 01451, Special Inspection, Observation, and Testing.
4. Tests and inspection data.
5. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data.
6. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01640, Manufacturers’ Services and Training.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on the Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on the Power Operated OPEN/CLOSE Valve Schedule, Power Operated Modulating Valve Schedule, Balancing Valve Schedule, and Self-Regulated Valve Schedule located on the Drawings.

2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations:
   a. B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.

2. Exterior coating for valves and hydrants shall be in accordance with Section 09900, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be "safety yellow."

B. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Gate Valves:

1. General:
   a. AWWA gate valves to be in full compliance with stated AWWA standard and the following requirements:
      1) Provide 2-inch operating nut and handwheel for AWWA gate valves 12 inches and smaller.
      2) Provide totally enclosed spur or bevel gear operator with indicator for AWWA gate valves 14 inches and larger.
      3) Provide Affidavit of Compliance per the applicable AWWA standard for AWWA gate valves.
      4) Mark AWWA gate valves with manufacturer's name or mark, year of valve casting, valve size, and working water pressure.
      5) Repaired AWWA gate valves shall not be submitted or supplied.

~~2. Type V130 Resilient Seated Gate Valve 2 Inches to 3 Inches:~~
~~a. Iron body, resilient seat, bronze stem and stem nut, threaded ends, nonrising stem, in accordance with AWWA C509, minimum design working water pressure 200 psig, full port, fusion-epoxy coated inside and outside per AWWA C550.~~
~~b. Manufacturer and Product: M&H Valve; AWWA C509.~~ [ADD. 3]

2. Type V130 Resilient Seated Gate Valve 2 Inches to 12 Inches:
   a. Ductile iron body, resilient seat, bronze stem and stem nut, threaded or flanged ends, non-rising stem, 2-inch square operating nut in accordance with AWWA C509, minimum design working

water pressure 200 psig, full port, fusion-epoxy coated inside and outside per AWWA C550.

b. Manufacturer and Product: M&H Valve; AWAA C509.[ADD. 3]

3. Type V150 Knife Gate Valve 24 Inches and Smaller:
   a. Bonnetless wafer body type, outside stem and yoke, rated for 150 psi cold water, ASME B16.1 flanged ends, self-cleaning, nonclogging, with round port, resilient neoprene seat, bidirectional drip-tight shutoff.
   b. Wetted metal parts and stem, Type 316 stainless steel, yoke sleeve bronze, gate finish ground both sides with a sharp knife edge.
   c. Packing system leak-tight seal around gate, valve superstructure and yoke designed for full peripheral access to gland bolts when valve is equipped with manual or power actuator.
   d. In compliance with MSS SP-81.
   e. Manufacturer and Product:
      1) WEY Valve Inc.; Model VSA.
      2) FNW; Figure 2020.
4. Type V160, Post Hydrant:
   a. Non-freeze, self-draining, compression type post hydrant with 2-3/16 inches main valve opening. Inlet connection shall be 2 inches FIP standard. Outlet shall be 2-1/2 inches NST standard. Depth of bury shall be 3 feet. All water flow shall pass through a 3-1/2 inch FBE coated steel pipe and cast iron top stock water way. All working parts shall be serviceable from above ground with no digging or replacement needed.
   b. Manufacturer and Product:
      1) Kupferle Foundry Company; Model Eclipse #2-3.0-A-A-B-C-X-X-A-X.
      2) No “or-equal.”

B. Ball Valves:

1. Type V301 Ball Valve 2 Inches and Smaller for General Water and Air Service:
   a. Two-piece, full port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 77-100.
         b) Nibco; T-585-70.

2) Soldered:
a) Conbraco Apollo; 77-200.
b) Nibco; S-585-70.

2. Type V304 Ball Valve 2 Inches and Smaller for General Water and Air Service:
a. Three-piece, full port, NPT threaded ends, bronze body and end pieces, hard chrome plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, zinc-plated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150 psi SWP, complies with MSS SP-110.
b. Manufacturers and Products:
1) Threaded Ends:
a) Conbraco Apollo; 82-100.
b) Nibco; T-595-Y.
c) Stockham; T-395 Series.
2) Solder Ends:
a) Conbraco Apollo; 82-200.
b) Nibco; S-595-Y.
c) Stockham; S-395 Series.

3. Type V306 Stainless Steel Ball Valve 2 Inches and Smaller:
a. Two-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end piece, NPT threaded ends, ASTM A276 Type 316 stainless steel ball, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 1,000 psig CWP, complies with MSS SP-110.
b. Manufacturers and Products:
1) Conbraco Apollo; 76F-100 Series.
2) Nibco; T-585-S6-R-66-LL.

4. Type V335 CPVC Ball Valve 2 Inches and Smaller:
a. Rated 150 psi at 100 degrees F, 80 psi at 140 degrees, with ASTM D1784, Type IV, Grade 1 chlorinated polyvinyl chloride (CPVC) body, ball, and stem, end entry, double union design, with solvent-weld socket ends or single union ball with flanged ends drilled to ASME B16.1, replaceable Teflon seat, Viton or Teflon O-ring stem seals, to block flow in both directions.
b. Manufacturer and Product:
1) Hayward; TB Series True Union.
2) No “or equal”.

5. Type V350 Hydronic Flow Balancing Valve 2 Inches and Smaller:
a. Reduced port, lead-free brass body, NPT threaded ends, calibrated stainless steel ball, 400 psig working pressure, hand dial with

calibrated dial indicator and memory stop screw, integral valved readout ports, and drain connection.

b. Size/Rating: As shown on Balancing Valve Schedule located on the Drawings.

c. Manufacturers and Products:

1) Bell & Gosset; Type CB Circuit Setter Plus.

2) Taco; ACUF Series Accu-Flo.

6. Type V355 Hydronic Flow Balancing Valve 2-1/2 Inches to 12 Inches:

a. Reduced port, cast iron body, 150-pound flanged ends, calibrated brass ball or globe, 175 psig working pressure, calibrated dial indicator and memory stop screw, integral valves readout ports, and drain connection.

b. Size/Rating: As shown on Balancing Valve Schedule located on the Drawings.

c. Manufacturers and Products:

1) Bell & Gossett; Type CB Circuit Setter Plus.

2) Taco; ACUF Series Accu-Flo.

C. Plug Valves:

1. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:

a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joint ends, unless otherwise shown.

b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.

c. For buried service, provide external epoxy coating.

d. Operators:

1) 3-Inch to 4-Inch Valves: Wrench lever manual.

2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.

e. Manufacturer and Product: DeZurik; Style PEC.

2. Type V408 Eccentric Plug Valve 3 Inches to 12 Inches for Digester Gas Service:
   a. Nonlubricated type rated 175 psig working pressure, bubble-tight shutoff with gas pressure from one direction, body cast iron with flanged ends, plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearing lubricated stainless steel, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber.
   b. Internal surfaces of valve body epoxy lined (except seat).
   c. Operators:
      1) 3-Inch and 4-Inch Valves: Wrench lever manual.
      2) 6-Inch through 12-Inch Valves: Totally enclosed, geared, manual operator, with handwheel, 2-inch nut, or chain wheel.
   d. Manufacturer and Product: DeZurik; Style PEC.

D. Butterfly Valves:

1. General:
   a. In full compliance with AWWA C504 and following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
      3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
      4) No travel stops for disc on interior of body.
      5) Self-adjusting V-type or O-ring shaft seals.
      6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
      7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
      8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
      9) Provide linings and coatings per AWWA, unless otherwise indicated on the Drawings or specified herein.
      10) Valves to be in full compliance with NSF/ANSI 61.

b. Non-AWWA butterfly valves to meet the following actuator requirements:
   1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on the Drawings or specified herein.

2. Type V512 Lug Butterfly Valve 2 Inches to 20 Inches for Digester Gas:
   a. Lug style, two-piece cast-iron body, one-piece Type 316 stainless steel thin-profile disc and stem, heavy-duty stem bushing, NBR stem seal, FKM (Viton) replaceable resilient seat, 50 psi pressure bi-directional bubble-tight rating, suitable for temperatures up to 250 degrees F, valve body to fit between ASME B16.1, Class 125/150 flanges. Supply reduced disc diameter, if available.
   b. Manufacturers and Products:
      1) Bray Controls; Model 21.
      2) Tyco/Keystone; Model 920.
3. Type V513 Butterfly Valve 2 Inches to 20 Inches:
   a. Lug style, ductile iron body, Type 316 stainless steel disc, Type 316 or Type 18-8 stainless steel one-piece stem, FKM (Viton) replaceable resilient seat, heavy-duty self-lubricating sleeve type bushings, NBR stem seal, 150 psi working pressure rating, valve body to fit between ASME B16.1, Class 125/150 flanges.
   b. For hot water applications, provide HTEPDM valve seat rated for service up to 300 degrees F.
   c. Manufacturers and Products:
      1) Bray Controls; Series 30/31.
      2) Tyco/Keystone; Model AR1/AR2.
      3) Crane/Centerline; Series 200.
4. Type V514 High Performance Butterfly Valve 2 Inches to 36 Inches:
   a. ASME B16.1, Class 150 wafer style, high performance type, carbon steel body, Type 316 stainless steel single or double offset disc, Type 316 stainless steel shaft and taper pins, PTFE seat, PTFE stem packing, stainless steel with RTFE thrust washer.
   b. Rated for temperatures up to 392 degrees F.
   c. Manufacturers and Products:
      1) Tyco/Keystone; K-Lok Series.
      2) DeZurik; BHP Series.

E. Check and Flap Valves:

1. Type V600 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-319, threaded ends.
      2) Milwaukee; Figure 509, threaded ends.
      3) Stockham; Figure B-309, soldered ends.
      4) Milwaukee; Figure 1509, soldered ends.
2. Type V608 Swing Check Valve 2 Inches to 24 Inches:
   a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with bronze seat, stainless steel hinge shaft.
   b. Valves, 2 inches through 12 inches rated 175-pound WWP and 14 inches through 24 inches rated 150-pound WWP. Valves to be fitted with adjustable outside lever and weight. Increasing-pattern body valve may be used where increased outlet piping size is shown.
   c. Manufacturers and Products:
      1) M&H Valve; Style 59, 159, or 259.
      2) Mueller Co.; No. A-2600 Series.
3. Type V632 Ball Check Valve 1-1/2 Inches to 2 Inches:
   a. Threaded end, Type 316 stainless steel body valve with cleanout and sinking type aluminum ball, vulcanized nitrile rubber exterior, NPT ends rated 150-pound working pressure, suitable for vertical up or horizontal flow.
   b. Manufacturer and Product: Flomatic; Series 208.

F. Self-Regulated Automatic Valves:

1. Type V710 Pressure-Reducing Valve 2 1/2 Inches and Smaller:
   a. Direct diaphragm operated, spring controlled, bronze body, NPT threaded ends, 200-psig rated minimum.
   b. Size/Rating: As shown in Valve Schedule located on the Drawings.
   c. Manufacturers and Products:
      1) Fisher; Type 75A.
      2) Watts; Series 223.
2. Type V712 Pressure-Reducing Valve 1-1/2 Inches to 2 Inches:
   a. Direct diaphragm, spring controlled valve.
   b. Cast-iron body, EPDM diaphragm and seat, brass internal wetted parts.
   c. NPT threaded ends, 50-psig rated.

d. Size/Rating: As shown in Valve Schedule located on the Drawings.
e. Manufacturer and Product: Fisher; S200 Series.

3. Type V713 Pressure-Relief Valve 2 Inches:
   a. Diaphragm operated cast iron and direct diaphragm, spring controlled, cast-iron body, aluminum diaphragm and spring case, nitrile disc/diaphragm/O-rings, internal relief, NPT threaded ends, 125-psig rated.
   b. Size/Rating: As shown in Valve Schedule located on the Drawings.
   c. Manufacturer and Product: Bell & Gossett; Model 4100.
4. Type V754 Air Release Valve 2 Inches to 4 inches:
   a. Suitable for Wastewater service, automatically exhaust small amounts of entrained air that accumulates in system. In CLOSED position, seat against resilient seat to prevent water leakage.
   b. Rated 232 psi working pressure, dual chamber Type 316 stainless steel funnel shaped body and polycarbonate float, nitrile O-rings, and removable Type 316 stainless steel mesh screen in primary chamber to protect valve assembly in secondary chamber. Flanged inlet. Operating pressure is as indicated on self-contained valve schedule located on the Drawings.
   c. Manufacturer and Product: Odour Technologies; VS-4 Smart Valve.
5. Type V781 Automatic Flow Control Valve 2-1/2 Inches and Larger:
   a. In-line automatic flow control with ductile iron body and stainless steel control cartridge and spring.
   b. Plus or minus 5 percent accuracy over a 8 psi to 32 psi differential range.
   c. Pressure/temperature test port with cap retainer.
   d. Wafer style body.
   e. Flow rate set at factory.
   f. Permanently marked to show direction of flow and flow rate.
   g. Size/Rating: As shown on Balancing Valve Schedule located on the Drawings.
   h. Manufacturers and Products:
      1) Griswold; Wafer AHU.
      2) IMI Design; AutoFlow Model WS.

G. Miscellaneous Valves:

1. Type V910 Telescoping Valve:
   a. Rack and pinion type with vertical floor stand, rack and pinion handwheel manual rising stem actuator; epoxy coated cast ductile iron pedestal, threaded Type 316 stainless steel stem; Type 316

stainless steel sliding tube and bail; and clear plastic stem cover, vented cover cap and position indication tape.
b. Stem guides if required shall be Type 316 stainless steel.
c. See the Drawings for mounting heights and adjustable depth requirements.
d. Anchor Bolts: Type 316 stainless steel.
e. Manufacturers:
1) Trumbull Industries, Inc.
2) Waterman.

2. Type V916 Cast Stainless Steel Mud Valve 3 Inches to 20 Inches:
a. Heavy-duty CF8M stainless steel yoke, flange, guides, and gate; Buna-N seat mechanically retained with Type 316 stainless steel fasteners, nonrising stem. Stainless steel casting to be passivated per ASTM A380. Type 316 stainless steel one-piece stem with integral thrust collar and coated with antigalling compound.
b. 2-inch operating nut, indicating stainless steel floorstand and wall bracket. Stem guides Type 316 stainless steel with bronze bushings for L/R of 200 maximum. Cast top and bottom stem couplings Type 316 stainless steel.
c. Manufacturers:
1) Troy Valve.
2) Trumbull Industries, Inc.

3. Type V925 Sampling Valve:
a. Type 316 stainless steel wetted parts, hand operated iron crank, piston to extend to inner surface of vessel or pipe, sealed by two compressible replaceable Teflon rings, one above discharge port and other below discharge port, 1-inch NPT inlet and 1-inch NPT outlet.
b. Manufacturers and Products: Strahman Valves, Inc.; Piston Type Sampling Valve.

4. Type V940 Solenoid Valve 1/4 Inch to 2 Inches:
a. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120V ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4 unless otherwise indicated. Size and normal position (when de-energized) as indicated on Power Operated OPEN/CLOSE Valve Schedule located on the Drawings.
b. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
c. Manufacturers:
1) ASCO.
2) Skinner.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
   a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
   b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
   c. Operator self-locking type or equipped with self-locking device.
   d. Position indicator on quarter-turn valves.
   e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Cranks on gear type operator.
   c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
   d. Valve handles to take a padlock, and wheels a chain and padlock.

B. Electric Operators, 120-Volt:

1. General:
   a. Unit shall be low profile to reduce the amount of required space.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of the valve.
   c. Provide operator mounting bracket to mount operator to valve providing minimal torque to piping system when operating.
2. Operator Operation – General:
   a. Suitable for full 90-degree rotation of quarter-turn valves.
   b. Manually override handwheel.
   c. Mechanical valve position indication.
3. Electronic Control:
   a. Torque limiting switches two single pole—double throw mechanical switches. Switches operate at any point in valve travel.
   b. Jammed-valve detection and protection.

c. Motor over-temperature detection and protection.
d. Travel limit switches, single pole double throw.

4. Modulating (M) Service:
   a. Operator rated for continuous duty with servo shall be rated for 100 percent modulating operation.
   b. Operator shall modulate based on an externally applied 4 to 20 mA dc signal.
   c. Operator shall be equipped with an electronic servo module for valve modulation.
      1) Module shall provide serial communications with provided cable for setup of valve operation.
   d. Local Indication and Control:
      1) Integral mechanical valve POSITION indication, 0 to 100 percent OPENED.
      2) Integral OPENED and CLOSED indication lights.
      3) Integral LOCAL-OFF-REMOTE (L-O-R).
      4) Integral OPEN momentary switch which causes the valve to stroke towards OPENED, as long as the OPEN switch is held, while the L-O-R switch is in LOCAL.
      5) Integral CLOSE momentary switch which causes the valve to stroke towards CLOSED, as long as the CLOSED switch is held, while the L-O-R switch is in LOCAL.
      6) Position valve proportionally 0 percent to 100 percent OPEN with external 4 mA dc to 20 mA dc signal while in REMOTE.
   e. Remote Indication and Control:
      1) Relay contact that closes when the valve is capable of being controlled remotely (L-O-R switch in REMOTE, etc.) for connection to and monitoring by Plant Control System.
      2) Limit switch that closes when the valve is fully OPENED for connection to and monitoring by Plant Control System.
      3) Limit switch that closes when the valve is fully CLOSED for connection to and monitoring by Plant Control System.
      4) Current Position Transmitter, 4 mA dcto 20 mA dc signal in proportion to 0 percent to 100 percent OPENED, with 0.5 percent accuracy and 0.5 percent repeatability, capable of driving a 500-ohm load, for connection to and monitoring by Plant Control System.
5. Manufacturer and Product:
   a. For explosion proof actuators: Beck Group, 57 Series.
   b. No Exceptions.
6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.

C. Electric Motor Actuators, 480 Volts:

1. General:
   a. Actuators of each type, as specified herein, shall be the products of a single manufacturer.
   b. The actuators and valves shall be furnished by the valve supplier as a unit assembly, complete in all respects.
   c. Electric motor actuators shall consist of a totally enclosed weatherproof electric drive unit and a totally enclosed gearbox.
   d. Actuator gearbox shall be grease-filled and suitable for operation at any angle, without voiding warranty. All gear housing, including actuator, shall be cast iron and all integral gearing shall be grease lubricated.
   e. Gearbox shall house and operate an appropriate stem coupling, as follows:
      1) Mechanical coupling of actuator to a quarter turn valve shaft with key shall be by removable splined bushing mating with integral spline of actuator drive sleeve.
   f. Gears shall be heat treated alloy steel or high tensile bronze, supported throughout by antifriction ball or roller bearings, and permanently lubricated at the factory.
   g. A lost motion device (independent of gear backlash) shall allow the motor to attain full speed before the load is encountered.
   h. Units shall be equipped with automatic double-acting geared limit switches and double-acting torque switches. Limit switches shall be geared directly to the operating gear train and shall be engaged and operable at all times, whether in motor or manual operation.
   i. The geared limit switches shall be internally wired to stop the motor at the fully OPEN and fully CLOSED positions. Switches shall be of the rotary drum wiping action contact type, field adjustable, and capable of being set either fully OPEN, fully CLOSED, or at any intermediate point. Use of cams or screws to set switches is unacceptable.
   j. Torque switches shall be internally wired so that, in the event of a mechanical overload in either direction, the motor will be stopped.
   k. Motorized actuators shall be equipped with side mounted handwheels for manual operation, which shall include an automatic clutch to positively disengage the handwheel at any time the drive motor is energized. Handwheel actuator shall be designed in such a way that failure of the motorized gearing will not prevent hand operation of the valve. Maximum rimpull for valve travel shall not exceed 60 pounds.

l. Operator components shall withstand a minimum manual input torque of 150 foot-pounds at extreme operator positions without damage.
m. Provide controls integral with the actuator unless otherwise specified in the Power Operated valve schedules. Where the Power Operated Valve schedules indicate control from an external control station, the external control station is provided per Section 17710, Control Systems: Panels, Enclosures, and Panel Components. For actuators with external control stations, provide automatic reset overload relay; terminal strips; controllers and protective circuitry; space heaters; and actuator controls to accept and seal-in dry contact OPEN and CLOSE commands from the external control station.
n. Electric motor actuators shall be provided with control features and operator stations as specified in this section and as noted in the Power Operated Valve Schedules located on the Drawings.
o. Each drive unit shall contain a properly sized, totally enclosed, nonventilated 460-volt, 60-Hz, three-phase motor; reversing motor controller; 480/120-volt control power transformer; and mechanical dial type position indicator.

2. Operator Type OPEN/CLOSE Service:
a. The actuators shall be power-actuated devices in accordance with AWWA C540 and as specified herein. Manufacturer shall provide certified drawings and affidavits of compliance as specified in AWWA C540.
b. Actuators shall be furnished and sized by the manufacturer for the service and differential pressures specified in the Power Operated Valve Schedules and shall be factory mounted. Actuator shall be sized to produce 1-1/2 times the required operating torque, but the stall torque of the motor shall not exceed the torque capacity of the operating device.
c. Motors shall conform to MEMA MG1, rated 60 starts per hour, with embedded thermostats.
d. Provide enclosure type and rating suitable for the classification of the area in which the operator is to be located. Enclosure ratings are indicated on the Power Operated Valve Schedules.
e. LOCAL-REMOTE Selector Switch, padlockable in each position:
1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
2) Auxiliary contact that closes in REMOTE position.
f. Accept remote dry contacts to actuate valve in REMOTE mode. One contact that closes to actuate valve to fully OPEN position, and one contact that closes to actuate valve to fully CLOSED position.

g. Actuator shall operate the valve from fully CLOSED position to fully OPEN positions, or the reverse, in the adjustable travel time specified in the Power Operated Valve Schedules.
h. Provide integral end position limit switches for remote monitoring of fully OPEN and CLOSED status. Provide four contacts, each selectable to indicate OPEN or CLOSED valve position. Switches shall be normally open contacts that close at the end position. Contacts shall be isolated and rated 10 amps at 120V ac. OPEN and CLOSED status signal contacts for remote indication shall be obtained from the same actuation mechanism as the contacts used for stopping the valve motor. It shall not be possible to adjust the valve motor stop contact and the associated valve status contact to actuate at different valve positions.

3. Operator Type Modulating Service:
   a. Size motor for continuous duty.
   b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
   c. LOCAL-REMOTE Selector Switch, pad-lockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
      2) 4 mA dc to 20 mA dc input signal to control valve in REMOTE position.
      3) Auxiliary contact that closes in REMOTE position.
   d. Valve shall close upon loss of signal unless otherwise indicated.
   e. OPEN and CLOSED indicating lights.
   f. AC motor with solid state reversing starter or DC motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
   g. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.
   h. Valve position output converter that generates isolated 4 mA dc to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24V dc.
4. All electric motor actuators shall be provided with control features as specified herein and as indicated on the Power Operated Valve Schedules.
5. Actuator Power Supply:
   a. 480-volt, three-phase unless otherwise indicated.
   b. Control power transformer, 120-volt secondary from actuator supplied transformer.
   c. Externally operable, pad-lockable power disconnect switch, mounted integrally with the actuator.

6. Performance Test Certificate:
   a. Each actuator shall be performance tested and individual test certificates shall be supplied. The test equipment shall simulate a typical valve load and the following parameter shall be reported:
      1) Current at maximum torque setting.
      2) Torque a maximum torque setting.
      3) Flash test voltage.
      4) Actuator output speed or operating time.
      5) Additional details including gear ratios, closing direction, and wiring diagram code numbers.
7. Startup Kit: Each actuator shall be supplied with a startup kit comprising installation instructions, electrical wiring diagrams and sufficient spare cover screws and seals to facilitate installation and startup.
8. Special Warranty and Experience Requirement: Complete actuator assembly shall be warranted for a minimum of 24 months of operation, regardless of pre-commissioning conditions. Technologies and devices used in actuators must have a minimum of 5 years of commercial operating experience for the actuator manufacturer.
9. Manufacturers and Products for Line Sizes 4 Inches and Larger:
   a. Quarter Turn Actuators, Open/Close or Modulating:
      1) Beck Group; 11 Series, all sizes.
      2) No exceptions.

2.07 ACCESSORIES

A. Tagging: Provide tagging per the requirements specified in Section 10400, Signage.

B. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.
2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
   a. Unless otherwise restricted or shown on the Drawings, install valve as follows:
      1) Liquids with Suspended Solids Service with Horizontal Flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
      2) Liquids with Suspended Solids Service with Vertical Flow: Install valve with seat in highest portion of valve (seat up).
      3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).

4. Butterfly Valves:
   a. Unless otherwise restricted or shown on the Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
   b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
   c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
   d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
   e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
5. Check Valves:
   a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
   b. Install valve in vertical flow (up) piping only for gas services.
   c. Install swing check valve with shaft in horizontal position.
   d. Install double disc swing check valve to be perpendicular to flow pattern when discs are open.
6. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station. For chainwheels or handwheels with chainwheel attachments directly mounted on the actuator shaft, add a roll pin at the end of the shaft to retain the chainwheel or handwheel if the pin sheared.

3.02 FIELD FINISHING

A. Field finish shall be in accordance with Section 09900 Painting and Coating, compatible with the factory finish and match the adjacent piping color.

3.03 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

3.04 MANUFACTURER'S SERVICES

A. Valve(s) as listed below require manufacturer's field services:

1. All valves with electric motor operators.

B. Manufacturer's Representative:

1. Present at Site for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for prestartup classroom or Site training of Owner's personnel, specific sessions as outlined in Section 01640, Manufacturers' Services and Training.

C. See Section 01640, Manufacturers' Services and Training, and Section 01756, Testing and Facility Startup.

END OF SECTION

SECTION 15205
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   f. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
2. Metal Bellows Field Finishing:
   a. Manufacturer’s recommended weld procedures for joining welded carbon steel piping to stainless steel bellows.

b. Welder qualifications for joining welded carbon steel piping to stainless steel bellows.
c. Product data for field-applied System No. 4, high temperature, epoxy lining and coating in accordance with Section 09900, Painting and Coating.

B. Informational Submittals:

1. Coupling Harness:
   a. Details, ratings, calculations, and test reports for thrust restraints relying on welded bars or rings.
   b. Weld procedure qualifications.
   c. Load proof-testing report of prototype restraint for any size coupling.
2. Basket Strainer:
   a. Manufacturer's written/printed installation instructions.
   b. Manufacturer's Certificate of Proper Installation, in accordance with Section 01640, Manufacturers' Services and Training.

C. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on the Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 CONNECTORS

A. Elastomer Bellows Connector:

1. Type: Fabricated spool, with single filled arch.
2. Materials: Nitrile tube and wrap-applied neoprene cover.
3. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with full elastomer face and steel retaining rings.
4. Working Pressure Rating: 140 psig, minimum, at 250 degrees F for sizes 12 inches and smaller.
5. Thrust Restraint: Control rods to limit travel of elongation and compression.
6. Manufacturers and Products:
   a. Garlock; Style 204.
   b. Unisource Manufacturing, Inc.; Style 1501.

B. Flexible Connectors for Gas Lines:

1. Corrugated, Type 316 stainless steel hose, with 10-inch live length and Type 316 stainless steel male NPT pipe connectors at each end.
2. Manufacturers and Product:
   a. Flexonics; Braided Rex-Weld.
   b. Kin-Line.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.
4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on the Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Flanged Coupling Adapter:

1. Anchor studs where required for thrust restraint.

2. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 913.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 912.

C. Restrained Flange Adapter:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than 2 times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

D. Restrained Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Smith Blair, Inc.; Model 975.

2.04 SEAL WATER ASSEMBLY

A. 1/2-Inch V301 Isolation ball valve as specified in Section 15202, Process Valves and Operators.

B. 1/2-Inch Rotometer as specified in Section 17316, Rotameters (Variable Area Flow Meters), and listed in Section 17901, Instrument List.

C. Seal Water Hose:

1. Provide 2-foot lengths.
2. Minimum Burst Pressure at 73 degrees F: 500 psi.

3. Maximum Operation Pressure at 73 degrees F: 125 psi.
4. Maximum Working Temperature: 150 degrees F.
5. Materials of Construction: Clear/Natural, 3/8-inch Polyethylene tube for water service.
6. 3/8-inch Polyethylene tube by NPT Acetal adapters size as required to connect to seal water piping and pump mechanical seal port.
7. Manufacturers and Products: Parker Hannifin Corporation; Series E.

D. 3/8-Inch Acetal Inline Check Valve:

1. Manufactures and Products: Parker Hannifin Corporation.

2.05 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
   a. Body: Malleable or ductile iron.
   b. Straps: Stainless steel.
   c. Hex Nuts and Washers: Stainless steel.
   d. Seal: Rubber.
5. Manufacturers and Products:
   a. Smith-Blair; Series 313 or Series 366.
   b. Dresser; Style 91.

2.06 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch or per standard detail.
2. Seep Ring:
   a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
   b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
   c. Continuously fillet weld on each side all around.
3. Factory Finish:
   a. Galvanizing:
      1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
      2) Electroplated zinc or cadmium plating is unacceptable.

b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09900, Painting and Coating.
c. Stainless Steel Sleeves: No factory finish.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
   a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
   b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer’s instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

2.07 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
   a. Rated for thrust load developed at 250 psi.
   b. Safety Factor: 2, minimum.
   c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.
5. Manufacturers:
   a. American Cast Iron Pipe Co.
   b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
   a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
   b. Continuously fillet welded on each side all around.

2.08 MISCELLANEOUS SPECIALTIES

A. Strainers, Water Service, 2 Inches and Smaller:

1. Type: Bronze body, Y-pattern, 200 psi nonshock rated, with screwed gasketed bronze cap.
2. Screen: Heavy-gauge Type 304 stainless steel or monel, 20-mesh.
3. Manufacturers and Products:
   a. Armstrong International; Inc.; Model F.
   b. Mueller Steam Specialty; Model 351M.

B. Digester 3 Scum Box NPW Spray Nozzle:

1. Quantity: Two (one installed, one spare).
2. Spray Angle: 45 degrees.
3. Material: Stainless steel.
4. Capacity: 4.2 gpm at 80 psi.
5. Size: 1/2-inch male NPT.
6. Manufacturer and Product: Spraying Systems Co.; FullJet B1/2GG-316SS16.

C. Digester 3 Floor Drains:

1. Materials: Type 304 stainless steel body and grate, butt weld or threaded outlet.
2. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 9725.

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 15200, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved Shop Drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18 inches or less from face of structures; joint may be flush with face.
2. Install a second flexible joint, whether or not shown.
   a. Pipe Diameter 18 Inches and Smaller: Within 18 inches of first joint.
   b. Pipe Diameter Larger than 18 Inches: Within two to three pipe diameter of first joint.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer’s instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.

2. Concrete Closures:
    a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
    b. Clean pipe surface before placing closure collars.
    c. Wet nonmetallic pipe thoroughly prior to pouring collars.
    d. Prevent concrete from entering pipe.
    e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
    f. Make entire collar in one placement.
    g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Grooved Joint and Flanged Piping Systems: Elastomer bellows expansion joint.
2. Nonmetallic Pipe: Teflon bellows expansion joint.
3. Screwed and Soldered Piping Systems: Copper or galvanized and black steel pipe expansion compensator, as applicable.
4. Air and Water Service above 120 Degrees F: Metal bellows expansion joint.
5. Pipe Run Offset: Flexible metal hose.

C. Weld-End Metal Bellows Installation:

1. Field Weld: Stainless steel bellows beveled ends joined to ALP carbon steel piping in accordance with approved welding procedures.
2. Lining:
    a. System No. 4, high-temperature epoxy, in accordance with Section 09900, Painting and Coating.
    b. Field apply lining to protect bellows and piping from rust at welded joint.
    c. Line both ends inside bellows, entire length of extension stub end, and from weld joint to a distance of 1 foot inside length of the carbon steel pipe.
3. Coating:
    a. System No. 4, high-temperature epoxy, in accordance with Section 09900, Painting and Coating.
    b. Field apply coating to protect bellows and piping from weather and rust at welded joint.

c. Coat both ends outside bellows, entire length of extension stub end, and from weld joint to a distance of 1 foot outside length of the carbon steel pipe.

D. Anchors and Anchor Walls: Install as specified in Section 15060, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

B. Plastic Piping: Nylon-coated iron.

3.06 OUTLET/TAPPING SADDLE

A. Install in accordance with manufacturer's written instructions.

3.07 COUPLINGS

A. General:

1. Install in accordance with manufacturer's written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. Do not remove pipe coating. If damaged, repair before joint is made.
4. Application:
   a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
   b. Concrete Encased Couplings: Flexible coupling.

3.08 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:

1. Nonmetallic Piping: Teflon bellows connector.
2. Copper Piping: Flexible metal hose connector.
3. Compressor and Blower Discharge: Metal bellows connector.
4. All Other Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.09 PIPE SLEEVES

A. Application:

1. As specified in Section 15200, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement using coated pipe penetrations as specified in Section 09900, Painting and Coating.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.11 MISCELLANEOUS SPECIALTIES

A. Basket Strainers:

1. Install in accordance with manufacturer’s instructions.
2. Field Quality Control:
   a. Conduct test on each basket strainer.

b. Test valves shall be tested for proper seating, travel, and operation.

3. Manufacturer's Services: Provide manufacturer's representative at Site in accordance with Section 01640, Manufacturers' Services and Training, and Section 01756, Testing and Facility Startup for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

END OF SECTION

SECTION 15210
HIGH-DENSITY POLYETHYLENE (HDPE) PRESSURE PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineer's (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B18.2.2, Square and Hex Nuts (Inch Series).
2. American Water Works Association (AWWA):
   a. C906, Polyethylene (PE) Pressure Piping and Fittings, 4 in. through 63 in., for Water Distribution and Transmission.
   b. Manual M55, PE Pipe - Design and Installation.
3. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   e. A536, Standard Specification for Ductile Iron Castings.
   f. A563, Standard Specification for Carbon and Alloy Steel Nuts.
   g. D638, Standard Test Method for Tensile Properties of Plastics.
   h. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
   i. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
   j. F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure.
   k. F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
4. Code of Federal Regulations (CFR): Title 49 Part 192.285, Plastic Pipe: Qualifying Persons to Make Joints.

5. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
6. Plastics Pipe Institute (PPI):
    a. Handbook of Polyethylene Pipe.
    b. Technical Note 38, Bolt Torque for Polyethylene Flanged Joints.
    c. TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

1.02 SUBMITTALS

A. Action Submittals:

1. Refer to Section 15200, Process Piping—General, for additional requirements.
2. Shop Drawings:
    a. Catalog information confirming pipe, fittings, and other materials conform to requirements of this section.
    b. Drawings of specific connection details.
3. Fusion equipment and data logger information of high-density polyethylene pipe. Fusion equipment data logger records shall be submitted in hard copy and electronic form.

B. Informational Submittals:

1. Refer to Section 15200, Process Piping—General, for additional requirements.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01640, Manufacturers’ Services and Training.
3. Certification from high-density polyethylene pipe (HDPE) manufacturer that Contractor is qualified to join, lay, and handle HDPE pipe.
4. Infrared temperature gun product data.
5. Certificates of qualification for persons to be fusing HDPE pipe.
6. Testing Plan:
    a. Submit at least 15 days prior to testing and include the following as a minimum:
        1) Testing dates.
        2) Piping systems and section(s) to be tested.
        3) Method of isolation.
        4) Method of conveying water from source to system being tested.
7. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
8. Test report documentation.

9. Fusion parameters including recommended limits of criteria recorded by data logger.
10. Fusion report for each joint, including information listed under Article Field Quality Control.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Pipe Manufacturer: Listed with Plastic Pipe Institute.
2. Persons fusing HDPE pipe shall be certified under 49 CFR § 192.285 and have minimum of 5 years of experience with fusing HDPE pipe and shall have received a minimum of 20 hours of training for fusing HDPE pipe from pipe supplier or fusing equipment supplier.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipping: Do not cut, kink, or otherwise damage pipe during transportation.

B. Storage:

1. Limit stacking of pipe to a height that will not cause excessive deformation of bottom layers of pipes under anticipated temperature conditions.
2. Where necessary, because of ground conditions, store pipe on wooden sleepers, spaced suitably and of such widths as not to allow deformation of pipe at point of contact with sleeper or between supports.
3. Keep pipe shaded from direct sunlight prior to installation in trench.

1.05 CONNECTIONS TO EXISTING PIPE

A. Fusing to Existing Pipe: Comply with manufacturer’s or distributor’s recommendations based on Site conditions and PPI TR-33.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe and Fittings:

1. Conform to requirements of ASTM F714.
2. In compliance with NSF 61.
3. Resin: Polyethylene resin shall meet or exceed requirements of ASTM D3350 for PE 4710 material with cell classification of 445474C,

or better. Pressure rating shall be based on hydrostatic design stress of 1,000 psi at 73.4 degrees F (AWWA C906).

4. Pressure Rating: Nominal SDR of 32.5.
5. Outside Diameter Basis: IPS.
6. Pipe lengths, fittings, and flanged connections to be joined by thermal butt-fusion shall be of a compatible resin mix for the fusion process.
7. Fittings:
    a. Sizes 6 Inches and Smaller: Molded and fabricated from polyethylene pipe.
    b. Sizes 8 Inches and Larger: Use thermal butt-fusion.
    c. Polyethylene fittings shall have same or higher pressure rating as pipe.

B. Backup Rings:

1. Convoluted for Flanged Connections:
    a. ASTM A536, ductile iron.
    b. Complete with one-piece, molded polyethylene flange adapters.
    c. Flanged Connections: Same or greater pressure rating as pipe.
2. Ductile Iron: Shop prime and shop finish coat in accordance with Section 09900, Painting and Coating, System No. 2, 2 coats, 16 MDFT.

C. Gaskets: Material, size, and thickness shall be as recommended by pipe or flange manufacturer, and in accordance with PPI Technical Note 38.

D. Joints:

1. Joints shall be thermal butt-fusion, except where connecting to unions, valves, and equipment with flanged or threaded connections that may require future disassembly and in specific locations as shown on the Drawings. Thermal butt-fusion in accordance with pipe manufacturer’s recommendation using certified operators as specified.
2. Depending on Site conditions, perform butt-fusion joining in or outside of excavation. The latest McElroy data Logger Model No. DL6301 shall be used to record proper joint fusion for each joint. No fused pipe joint shall be installed until it has passed according to the data logger output. Hard copy and electronic records for each passed joint shall be submitted. Butt-fusion shall be performed in accordance with pipe manufacturer’s recommendations as to equipment and technique.
3. Electrofusion joints shall only be allowed for closures and where approved by Engineer.

E. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no

subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible. Backfill with controlled low strength fill (CLSF) as specified in Section 02320, Trench Backfill.

F. Bolts, Nuts, Washers:

1. Type 316 stainless steel, ASTM A193/A193M, Grade B8 hex head bolts; and ASTM A194/A194M, Grade 8 hex head nuts.
2. Bolts: Fabricated in accordance with ASME B18.2.2 and provided with washers of same material as bolts.
3. For flanged joints, bolts, and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to manufacturer's standard. Retorque after 4 hours. Refer to Plastic Pipe Institute (PPI), Technical Note 38, Bolt Torque for Polyethylene Flanged Joints for additional requirements.

G. Products that restrain HDPE pipe with wedges, machined serrations, or clamps are not acceptable.

H. Electrofusion Branch Saddles:

1. Material: HDPE.
2. Method of Attachment: Electrofusion.
3. Temporary Method of Attachment: Integrated straps or bands.
4. Designed for HDPE pipe.
5. Manufacturers:
   a. Central Plastics Company.
   b. ISCO Industries.
   c. HDPE Supply.
   d. Chevron Phillips Pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install polyethylene pipe in conformance with AWWA M55, PPI TR-33, ASTM F2620, and pipe manufacturer's recommendations.
2. Joining: Butt-fuse pipes and fittings in accordance with pipe manufacturer's recommendations. Depending on Site conditions, perform butt-fusion joining in or outside of excavation.

3. Remove and extract internal fusion bead from pipe.
    a. Verify complete internal fusion bead removal was performed. Accomplish by examination of extracted internal fusion bead or by means of closed circuit television (CCTV) examination.
    b. Extracted Internal Fusion Bead:
        1) Appearance shall have same double roll back semblance as does the external fusion bead.
        2) Possess smooth root cut, or pipe smoothness and shall be verified by means of closed circuit television (CCTV) examination.
    c. Removal of internal bead may include pipe wall mass. However, wall mass that is removed shall not exceed 1/10th of pipe wall thickness.
4. If HDPE pipe surface temperature is above 80 degrees F, as measured with infrared temperature gun, allow pipe to cool prior to making any connections to flanges, existing pipeline systems, or structures.
5. Connect HDPE pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems with flanged connections as follows:
    a. Polyethylene flange adapter, thermally butt-fused to end of pipe. Flange “stub ends” are not allowed.
    b. Convoluted backing flange, as specified.
    c. Bolt and nut of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer’s standard.
    d. Follow requirements of PPI Technical Note 38 including mandatory 4-hour bolt retorquing.
6. Special Precautions at Flanges: Support polyethylene pipe connected to heavy fittings, manholes, and rigid structures in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.
7. Minimum Long-Term Field Bending Radius: Restricted to limits recommended by AWWA M55, Table 8-2.

B. Placement in Trench:

1. Handle joined pipeline in such a manner that pipe is not damaged by dragging it over sharp and cutting objects.
2. Position slings for handling pipeline away from butt-fused joints.
3. Remove sections of damaged pipe and replace it with undamaged pipe. Damaged pipe is defined as pipe with kinks or gouges exceeding 10 percent of pipe wall thickness.
4. Exercise care when lowering pipe into trench to prevent damage or twisting of pipe.

5. Snake pipe from one side of trench to other to allow for thermal and settling movements, and as recommended by pipe manufacturer.
6. Temperature Requirements: Immediately backfill as specified as soon as pipe is laid in the trench to prevent temperature fluctuations. Cover all exposed HDPE near connections as required to prevent temperature fluctuation. Do not connect HDPE to new structures, thrust collars or existing pipelines until the pipe has been backfilled for a minimum of 48 hours.
7. At flanges, valves, and connections, excavate out trench bottom sufficiently to ensure clearance between undisturbed trench bottom and flange, valve, or connection.

3.02 FIELD QUALITY CONTROL

A. Joint Fusion:

1. Measure and log each joint fusion by an electronic monitoring device (data logger) affixed to fusion machine, and shall be capable of being retrieved electronically. Data to be logged shall include the following:
   a. Pipe size and dimensions.
   b. Machine model and size.
   c. Operator identification.
   d. Job identification number.
   e. Weld number.
   f. Fusion, heating, and drag pressure settings.
   g. Heater plate temperature.
   h. Time stamp showing when weld was performed.
   i. Heating and curing time of weld.
   j. Curing temperature readings and time stamps of readings.
   k. Error messages and warnings for out of range temperature or pressure settings.
   l. The welding machine controller (or electrofusion controller) shall be calibrated and the calibration is current (not expired).
2. In addition to logged items above, the following shall be logged or annotated on report:
   a. Location of joint being fused by pipeline station or by reference to pipe Shop Drawing.
   b. Ambient temperature and humidity.
   c. If internal bead was removed.

B. Joint Weld Testing:

1. Test Procedure: ASTM D638.
2. Specimens: Cut pipe 12 inches on each side of field made joint. Rejoin ends and proceed with Work.
3. Test Frequency:
   a. One for each run of HDPE pipe.
   b. Each Test Failure: Two additional joints selected at random by Engineer.

3.03 MANUFACTURER'S SERVICES

A. Provide pipe manufacturer's representative at Site in accordance with Section 01640, Manufacturers' Services and Training, for assistance during pipe joining operations and pipe installation.

END OF SECTION

SECTION 15500
HEATING BOILERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA).
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): 90.1, Energy Standard for Buildings except Low-Rise Residential Buildings.
3. American Society of Mechanical Engineers (ASME):
   a. CSD-1, Controls and Safety Devices for Automatically Fired Boilers.
   b. Section IV, Rules for Construction of Heating Boilers.
4. FM Global (FM).
5. Industrial Risk Insurers (IRI).
6. National Electrical Manufacturers' Association (NEMA): MG 1, Motors and Generators.
7. National Fire Protection Association (NFPA):
   a. 54, National Fuel Gas Code.
   b. 70, National Electrical Code (NEC).
8. Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA): Seismic Restraint Manual: Guidelines for Mechanical Systems.
9. UL: 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.02 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, complete bill of materials, and descriptive literature that include make, model, dimensions, weight of equipment, and electrical schematics, for products specified.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.
3. Controls and instrumentation submittals in accordance with Section 17710, Control Systems Panels, Enclosures, and Panel Components.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements, for the boiler minimum efficiency per ASHRAE 90.1.
3. Manufacturer's product information for the following:
   a. Energy-efficient motors.
   b. Boiler thermal performance and minimum efficiency.
   c. Boiler emissions performance.
4. Recommended procedures for protection and handling of equipment and materials prior to installation.
5. Component and attachment testing seismic certificate of compliance as required by Section 01451, Special Inspection, Observation, and Testing.
6. Operation and Maintenance Data as specified in Section 01782, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01640, Manufacturers' Services and Training.

1.03 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under the NEC.

B. Products manufactured within scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

1.04 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturer recommended spare parts including part numbers, current price list, and contact for purchasing.

1.05 WARRANTY

A. Provide a Manufacturer's warranty meeting the requirement of Section 00700, General Conditions.

1. The pressure vessel shall be guaranteed against thermal shock for the lifetime of the boiler when utilized in a closed loop hydronic heating system with a temperature differential of 120 degrees F or less. The boiler pressure vessel shall be guaranteed accordingly without a

minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.

2. The pressure vessel, tubes and tube sheets (heat exchanger) shall be guaranteed against flue gas corrosion and materials/workmanship for a period of 15 years. The condensate collection pan shall be guaranteed for 20 years. The burner cylinder shall be warranted for a period of 5 years.
3. All parts not covered by the above warranties shall carry a 2-year parts and labor warranty from startup, or 30 months from shipment, whichever occurs first. This shall include all electrical components and burner components.

PART 2 PRODUCTS

2.01 GENERAL

A. Noise Level: When in operation, no piece of equipment shall exceed 72 dBA.

B. Heating equipment shall have minimum operating efficiencies as specified in the 2021 Oregon Energy Efficiency Specialty Code.

C. Boiler Assemblies: Built in accordance with ASME Section IV.

D. The design of the boiler package system as shown on the Drawings are based upon the equipment from the first-named manufacturer listed in this section. The Contractor shall be responsible for making all necessary changes to the facility design to accommodate the equipment, including but not limited to, layout changes and interface connections to other work and equipment which are different than that shown on the Drawings. The Contractor shall be responsible for coordinating this work and the changes shall be at the sole expense of the Contractor. At a minimum these changes include:

1. Layout and mounting of the equipment, including concrete equipment pads.
2. Coordination of equipment elevations.
3. Rerouting of any piping required to meet the manufacturer’s system requirements.
4. Additional utilities required to support manufacturer’s system.
5. Provisions required by AHJ for approval.

E. The control functions contained and described herein are intended to provide proposed minimum performance requirements. They do not necessarily identify every control function, connection, communications, or equipment to achieve the requirements. Additional specificity and details shall be provided within the submittals.

2.02 CONDENSING BOILERS

A. Description: Each unit shall be a down-fired firetube type complete with burner and automatic controls. The boiler, with all piping and wiring, shall be a factory package. Each boiler shall be neatly finished, thoroughly tested and properly packaged for shipping. Boiler design and construction shall be in accordance with Section IV of the ASME Code for hot water heating boilers with a maximum working pressure of 125 psig.

B. Heat Exchanger:

1. Duplex stainless steel tubes, tube sheets, and combustion chamber. The heat exchanger shall be a single-pass, counter-flow arrangement.
2. The firetubes shall be duplex stainless steel, fitted with aluminum internal heat transfer fins.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Flow Requirements: Boiler shall be low flow tolerant without minimum requirements or the use of a flow switch.

E. The boiler pressure vessel shall have a minimum of 42 gallons of water volume/1,000 mbh input.

F. The boiler shall have a minimum of 200 square feet/1,000 mbh of effective fireside heating surface.

G. Burner:

1. Natural gas, forced draft burner mounted in and integral with the boiler hinged top door so when the door is OPENED the burner head, furnace, tubesheet, and tube entrances are exposed. The burner door shall utilize easy removable threaded handles, and the burner shall swing upward on gas assist piston arms, one on each side to provide open support of the burner assembly.
2. The burner shall be a linkage-less, self-regulating, air-fuel ratio gas valve-venturi system. Burner regulation shall be accomplished without the use of fuel/air mixing valves.
3. The burner shall achieve sub 20 ppm NOx when firing on natural gas at all firing rates.
4. Burner and fireside access shall be able to be performed by one service technician.
5. To ensure that the flue is not blocked, the burner shall include a High Air Pressure Switch sensing the outlet pressure connection relative to stack backdraft.

H. Burner Head:

1. Shall be constructed of a stainless steel metal fiber for solid body radiation of the burner flame. Combustion shall take place on the surface of the burner mantle, which shall be constructed of a woven stainless steel metal fabric resulting a 360-degree low temperature radiant flame.
2. Burner shall be capable of minimum 10:1 fully modulating turndown (Natural gas).
3. Burner shall maintain no more than 7 percent O_2 levels throughout the firing rate without additional sensors, linkages, or controls.
    a. The pre-mix design shall utilize a variable speed fan connected to a venturi to simultaneously modulate the fuel and air for a minimum 10:1 turndown. The gas valve-venturi design shall also act as a method for compensating for changes in barometric pressure, temperature, humidity and air-density so the excess air levels are not adversely affected by changes in atmospheric conditions. External linkages and single speed fans shall not be acceptable.

I. Blower:

1. Boiler shall be equipped with a pulse width modulating centrifugal fan to precisely control fuel/air mixture for burner firing and to pre-purge and post-purge the combustion chamber.
2. The blower motor shall have a variable speed ECM motor with integrated drive electronics.

J. Ignition:

1. Pilot ignition with 100 percent main-valve shutoff with electronic flame supervision.
2. Provide UV scanner for flame supervision.
3. Combustion air proving switch shall be furnished to ensure sufficient combustion airflow is present for burner ignition firing.

K. Casing:

1. Jacket: 18-gauge metal cabinet with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Powder-coated protective finish.
4. Insulation: Minimum 2-inch thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

L. Boiler Cabinet:

1. Minimum 2-inch thick, mineral-fiber insulation surrounding the heat exchanger.
2. Metal enclosure finished in manufacturer’s standard heat-resistant primer and enamel.

M. Gas Train:

1. Meets requirements of CSA/UL and ASME CSD-1.
2. FM and IRI approved.
3. Manual main and pilot shutoff valves.
4. Gas pressure regulator.
5. Upstream and downstream manual test cocks.
6. Modulating fire control with 10:1 turn down ratio.
7. Union connection to permit burner servicing.
8. Electronic ignition.
9. Low Gas Pressure Interlock, manual reset.
10. High Gas Pressure Interlock, manual reset.
11. Unibody double safety gas valve assembly.

N. Boiler Trim:

1. Safety valve(s) shall be ASME Section IV approved side outlet type mounted on the boiler air vent outlet. Size shall be in accordance with code requirements and set to open at 125 psig.
2. Temperature and pressure gauge shall be mounted on the water outlet.
3. Solid State Low water cut-off probe control with manual reset and test switch.
4. Manual Reset High Limit Temperature sensor; range not to exceed 210 degrees F and shall be an integral device of the Boiler Burner Control and UL Recognized as a limit control.
5. Outlet water supply sensing probe for operating water limit setpoint.
6. Return water-sensing probe for operating limit setpoint.
7. Drain valve.
8. Automatic air vent.
9. Auxiliary low water cutoff.
10. Stack Temperature Sensor: UL Recognized as a limit control.
11. Condensate Neutralization Kit Tank: Axiom; NT15, “or-equal.”

O. Boiler Control Panel:

1. The boilers shall include integrated factory mounted boiler control panel which shall be microprocessor based capable of sequence indication, fault reset, mode selection, and set-point adjustment. Each boiler to have

control panel mounted at the front of the cabinet for easy viewing from the floor level.

2. Boiler software shall be unlocked/unprotected.
3. Boilers shall automatically start after a power failure.
4. Control board shall provide for flame safeguard and shall perform the following functions:
    a. Burner sequencing with pre-purge, electronic spark ignition, and post purge.
    b. Electronic flame sensing to prove combustion.
    c. Flame supervision including a history of operating hours, number of cycles, and the most recent 15 lock-outs or faults.
    d. 7-inch colored touchscreen display interface to display operational information, status, and fault history.
    e. PID modulating control of the variable speed combustion fan and firing capacity to meet supply water temperature set-point.
    f. Gas train supervision, high and low.
    g. Combustion air proving switch supervision.
    h. High air pressure switch supervision.
    i. Communicate with 7-inch display for set-up, troubleshooting, and operational status.
    j. Include Modbus connection and Modbus to ethernet IP gateway for connection to plant SCADA network.
5. Controller to have the ability to operate as master boiler control panel for up to two boilers. As master boiler control panel, controller will stage each connected boiler and modulate the capacity of each to achieve heating water set point. The control shall stage and modulate the boilers utilizing firing rate threshold staging and parallel modulation to optimize condensing potential while minimizing energy wasting short cycling. This strategy takes full advantage of the inverse efficiency characteristic (lower fire rate, higher efficiency) of condensing boilers. The control shall monitor supply water temperature, return water temperature and shall communicate between boilers via RS-485 network wiring. The controls shall have a built-in feature to switch host boiler status among the client boilers if the assigned host boiler is not operational in a lead/lag setting. Network connection at master boiler controller will pass all operational information for connected boiler to the network.
6. General:
    a. See Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, for general instrumentation and control requirements. Instrumentation, control, and electrical components provided under this section shall comply with requirements of Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

b. See Section 17710, Control Systems: Panels, Enclosures, and Panel Components, for general control panel requirements.

7. Enclosure: Boiler mounted NEMA 1, metal, factory finished, with hinged lockable door.
8. Disconnect switch.
9. Control Power: Integral control transformer with fused primary and secondary windings derived from single point power connection.
10. Operating and safety controls.
11. Integral oxygen trim control.
12. Operator Control and Indicators:
    a. As a minimum, the following operator interface functions and displays shall be provided on the panel exterior:
        1) Control ON/OFF Selector switch.
        2) Main power ON/OFF indicating light.
        3) Operator interface screen (OIU).
        4) LOCAL/REMOTE control selector switch.
        5) Warm-up mode indicating light.
        6) Main NG gas valve ON indicating light.
        7) Flame failure ALARM indicating light.
        8) Low water cutoff ALARM indicating light.
        9) Flame failure ALARM indicating light.
        10) High water temperature shutdown ALARM indicating light.
        11) Safety shutdown ALARM indicating light.
        12) ALARM Horn.
        13) ALARM silence button.
    b. As a minimum, the following operator interface functions and displays shall be provided through the operator interface (OIU):
        1) ALARM type indication.
        2) ALARM RESET.
        3) LOCAL/REMOTE mode indication.
        4) Warm-up mode indication.
        5) LOCAL temperature control setpoint.
        6) REMOTE temperature control setpoint.
        7) LOCAL warm-up temperature control setpoint.
        8) REMOTE warm-up temperature control setpoint.
        9) Firing rate.
        10) Inlet water temperature.
        11) Outlet water temperature.
        12) Elapse time meter.
13. Functional Requirements:
    a. As a minimum, the following functions shall be provided:
        1) LOCAL Mode Operation:
            a) Warm-up Mode: Upon being enabled to operate from the local ON/OFF control switch, the boiler shall hold the firing rate at the minimum rate until the outlet

water temperature reaches the LOCAL warm-up water temperature control setpoint.

b) Temperature Control Mode: Upon release from warm-up mode, the boiler shall modulate the firing of the LOCAL to maintain the boiler outlet temperature at the LOCAL temperature control setpoint.

2) REMOTE Mode Operation:

a) Warm-up Mode: Upon being enabled to operate when the REMOTE ENABLE signal is received, the boiler shall hold the firing rate at the minimum rate until the outlet water temperature reaches the REMOTE warm-up water temperature control setpoint.

b) Temperature Control Mode: Upon release from warm-up mode, the boiler shall modulate the firing of the REMOTE to maintain the boiler outlet temperature at the REMOTE temperature control setpoint.

P. Boiler Controls:

1. Boiler Pump Run Command – Output.
2. Remote Emergency Shutdown – Input.
3. Circulation Pump Status/Start Permissive – Input.

Q. Control Interface with Plant Control System:

1. External Interfaces:
   a. Minimum Ethernet/IP protocol signals:
      1) Boiler ON command.
      2) Boiler temperature setpoint.
      3) Boiler RUNNING status.
      4) Boiler FAULT/ALARM status.
      5) Boiler speed feedback.
      6) Elapsed time meter.
      7) Inlet and outlet temperature.

R. Capacity: 105 nominal boiler hp, 4,000 mbh input, 3,520 mbh gross IBR output, 480-volt, three-phase power supply, 4,000 cubic feet per hour gas firing rate at 7 inches water column gas supply pressure and 1,000 Btu per cubic foot heat value.

S. Manufacturers and Products:

1. Cleaver Brooks; Model CFC-E 4000.
2. ”Or-equal.”

2.03 COMBUSTION AIR INTAKE

A. For Gas-Fired Water Heaters: Complete system, PVC pipe, vent terminal with screen, inlet air coupling, and sealant.

2.04 BOILER STACK

A. Double Wall Boiler Stack:

1. UL listed, Type IPS.
2. Stainless steel inner and outer jacket.
3. Insulation: 1-inch fiberglass insulation between jackets.
4. Insulating thimble.
5. Tee section with drain where stack is offset.
6. Manufacturer’s standard fittings as required.
7. Configured to allow both a 8-foot 10-inch minimum cantilevered stack height above roof elevation without the use of guy wires or external supporting structure.
8. Stack test ports consisting of two 3-inch diameter, blind flanged ports installed with 90-degree separation located 4 feet above roof elevation.
9. Stack design shall include all required supporting structure. Provide support system compatible with special requirements of double tee structure, coordinated with the owner and the structural engineer of record.
10. Provide the boilers with common breeching and routed through an existing 26-inch diameter rooftop penetration. Equip breeching branch connections to each boiler with motorized ON/OFF rated for flue gas temperatures up to 550 degrees F with control and power supplied by the boiler.
11. Coordinate and provide all additional stack accessories required by boiler manufacturer.

B. Manufacturers and Product:

1. Selkirk; Metalbestos.
2. Van Packer.

2.05 ACCESSORIES

A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Provide in accordance with Section 10400, Signage.

C. Anchor Bolts: Galvanized sized by equipment manufacturer, and as specified in Section 05500, Metal Fabrications. Coat in accordance with Section 09900, Painting and Coating.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test equipment furnished.

1. Functional Test: Perform manufacturer's standard test.
2. Simulate to the maximum extent possible all the control functions of the Boiler control panel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Boiler:

1. Install in accordance with manufacturer's recommendations.
2. Pipe drains and relief valve discharges to floor drain, terminating with an elbow discharging downward.
3. Provide chain wheel operators on boiler isolation valves higher than 7 feet above floor level.
4. Flush out boiler and connecting piping prior to initial fill.
5. Provide seismic restraints for the boiler utilizing lateral and vertical motion limiters described in SMACNA "Seismic Restraint Manual: Guidelines for Mechanical Systems."

B. Boiler Stack and Breeching:

1. Assemble individual sections of stack together to provide a completely supported stack.
2. Follow manufacturer's drawings and directions for installation of stack.

C. Gas Vent Stack: Install in accordance with manufacturer's recommendations and requirements of NFPA 54.

D. Boiler Feed System: Install in accordance with manufacturer's instructions.

E. Boiler Blowdown Separator: Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization, and shall include:

1. Demonstrate that boiler, burner, controls, and accessories comply with requirements of this section as proposed by the boiler and accessories supplier. Pre-test all items prior to scheduling the final testing that will be witnessed by the test engineer.
2. Readings at different firing rates (20 percent, 50 percent, 75 percent and 100 percent) of load for the modulating burner shall be taken with a written report of the tests submitted to the engineer. The reports shall include readings for each firing rate tested and include stack temperatures, O2, CO, NOx, and overall boiler efficiency.
3. Auxiliary Equipment and Accessories: Observe and check all valves, draft fans, electric motors and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctioning, defects, and non-compliance with referenced standards or overloading as applicable.
4. Contractor Startup shall include:
    a. Fireside inspection.
    b. Set up fuel train and combustion air system.
    c. Set up operating set points.
    d. Check all safeties, including flame safeguard, LWCO, airflow, fuel pressures, high limits.
    e. Set up and verify efficiencies at 20 percent, 50 percent, 75 percent, and 100 percent.
    f. Set up and verify burner turndown.
    g. Additional inspections and set up tasks as required or recommended by the boiler manufacturer.

B. Functional Tests:

1. Conduct on each boiler assisted by manufacturer’s representative, as follows:
    a. Startup Assistance:
        1) Inspect all gas piping, system piping with accessories, and boiler breeching.
        2) Initial startup of boiler and observe four subsequent starts.
        3) Adjust devices in fuel piping circuit.
        4) Perform checks on operating and safety controls.
        5) Calibrate integral controls, gauges, and thermometers.

C. Performance Test:

1. Conduct on each boiler assisted by manufacturer's representative.
2. Perform under actual or approved simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.

D. Training: Minimum 4 hours instructional time with Owner's personnel reviewing maintenance manuals and showing how each step is to be properly performed.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative for detailed classroom and hands-on training in accordance with Section 01640, Manufacturers' Services and Training, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

END OF SECTION

SECTION 15720
AIR HANDLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Movement and Control Association International, Inc. (AMCA):
   a. 201, Fans and Systems.
   b. 203, Field Performance Measurement of Fan Systems.
   c. 204, Balance Quality and Vibration Levels for Fans.
   d. 300, Reverberant Room Method for Sound Testing of Fans.
   e. 301, Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
   f. 99-0401, Classifications for Spark Resistant Construction.
   g. 99-2408, Operating Limits for Centrifugal Fans.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 15, Safety Standard for Refrigeration Systems.
   b. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   d. 62.1, Ventilation for Acceptable Indoor Air Quality.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

6. CSA America (CSA):
   a. B149.1, Natural Gas and Propane Installation Code.
   b. Z83.4, Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
   c. Z83.18, Recirculating Direct Gas-Fired Industrial Air Heaters.
7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 841, Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
8. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
    a. 54, National Fuel Gas Code.
    b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
    c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Occupational Safety and Health Act (OSHA).
12. Society of Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
13. UL:
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. ac: alternating current.
2. AFD: Adjustable Frequency Drive.
3. AHU: Air Handling Unit.
4. cfm: cubic feet per minute.
5. CISD: Chemical Industry, Severe-Duty.
6. dB: Decibel.
7. DX: Direct Expansion.
8. DWDI: Double Width, Double Inlet.
9. ETL: ETL Testing Laboratories, Inc.
10. FM: Factory Mutual Insurance.
11. fpm: feet per minute.
12. hp: Horsepower.
13. IAQ: Indoor Air Quality.

14. IEC: International Electro-technical Commission.
15. IRI: Industrial Risk Insurance.
16. MAU: Make-Up Air Unit.
17. NRC: Noise Reduction Coefficient.
18. OD: Outside Diameter.
19. ODP: Open Drip Proof.
20. O&M: Operations and Maintenance.
21. psi: pounds per square inch.
22. PVC: Polyvinyl Chloride.
23. rpm: revolutions per minute.
24. SCR: Silicon Control Rectifier.
25. SWSI: Single Width, Single Inlet.
26. TEFC: Totally Enclosed, Fan Cooled.
27. UV: Ultra Violet.
28. VFD: Variable Frequency Drive.
29. WC: Water Column.
30. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawings for products specified, including, as a minimum:
    a. Unit identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights for unit, including fully assembled and shipping sections.
    e. Acoustics:
        1) Fan sound power level data (ref. 10 to power minus 12 Watts) at design operating point, based on AMCA 300 for unit discharge, inlet and casing.
        2) Additional requirements (including by others) to achieve specified sound performance levels.
    f. Fans:
        1) Type, size, quantity, class, drive arrangement, discharge, rotation, and bearings.
        2) Wheel type, diameter, rpm, and tip speed.
        3) Performance curves indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum safe operating rpm).

d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.

g. Coils:
1) Type, quantity, dimensions, material of construction, coatings, if applicable, energy transfer capacity, air pressure drop, air inlet, and discharge temperature at design conditions.
2) Hydronic Coils: Water pressure drop at design conditions, water inlet and discharge temperature at design conditions, piping connection data, coil fin spacing, coil row depth.
3) DX Coils: Refrigerant saturated suction temperature at design conditions, refrigerant piping configuration (row split, face split, intertwined), coil fin spacing, coil row depth.
4) Coil pull details and dimensions for service.

h. Motor(s) type, quantity, and performance data.
i. Air filter(s) type, quantity, and performance data.
j. Unit capacities and ratings, including airflow and static pressure summary.
k. Construction materials.
l. Power and control wiring diagrams, including terminals and numbers.
m. Vibration Isolation:
1) Vibration isolation methods with maximum deflection data.
2) Additional requirements (including by others) to achieve specified vibration isolation levels.
n. Factory finish system, with color selection charts where applicable.
o. Corrosion protection coating product data.

2. “Or-Equal” Equipment:
a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on the Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
b. Where submitted equipment results in change to ductwork and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.

2. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements.
3. Sample copy of guarantee.
4. Manufacturer's Test Reports for the following:
   a. Water heating coil.
   b. DX cooling coil.
5. Recommended procedures for protection and handling of products prior to installation.
6. Manufacturer's installation instructions, including component spacing requirements.
7. Operation and Maintenance Data:
   a. In conformance with Section 01782, Operation and Maintenance Data.
   b. Include as-built version of equipment schedules.
   c. Methods for accessing components for maintenance with required service clearances.

1.04 QUALITY ASSURANCE

A. Fans: Licensed to bear AMCA seal for air flow and sound performance.

B. Manufacturer's Qualifications:

1. The air handling unit manufacturer shall have been successfully manufacturing air handling units for a period of no less than 5 years.
2. Manufacturer's qualifications are subject to review by the Owner/Engineer to determine acceptance.

C. Fan Performance:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure.
3. Motor shall not operate into motor service factor in any listed case.
4. Accommodate drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA 203, Appendix L.

D. Thermal Insulation: Shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E84 and UL 723).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Air handling unit manufacturer shall coordinate with the Contractor as to the requirements for proper delivery, storage, and handling of the air handling unit and its components required in this specification to ensure that the unit is properly cared for prior to final installation.

1.06 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Delivery: In accordance with Section 01600, Product Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to the Drawings.

2.02 SPARK RESISTANT CONSTRUCTION

A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

2.03 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

2.04 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in fan equipment schedule.

B. Perform noise tests in accordance with AMCA 300.

2.05 FINISHES

A. Carbon Steel Parts: Factory finished as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

2.06 AIR HANDLING UNITS—MODULAR

A. General:

1. Modular air handling unit, constructed by assembly of factory-fabricated modules containing components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices, and accessories.
2. Required module types as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Module Casing:

1. General:
   a. Each module fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels, mechanically fastened to structural metal internal frame.
   b. Wall panels shall be easily removable. Panel removal shall not affect structural integrity of unit.
   c. Height and width dimensions identical for each module type, for a given unit size.
   d. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   e. All casing insulated, formed and reinforced sheet metal panels, flat panel design not acceptable.
   f. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph Insulation. Units are double wall, unless noted otherwise.
   g. Each panel shall be removable from outside of unit without affecting unit structural integrity.
2. Fasteners: Constructed of same material as respective module panel materials.
3. Outer Panels:
   a. Material: G-90 galvanized steel.
   b. Walls: Minimum 16-gauge (0.0625-inch) thickness sheet metal.
   c. Roof: Minimum 16-gauge (0.0625-inch) thickness sheet metal.

4. Inner Panels:
   a. Walls and Roof:
      1) Material: G-90 galvanized steel.
      2) Minimum 20-gauge (0.0348-inch) thickness sheet metal.
   b. Floor Plate:
      1) Material: G-90 galvanized steel.
      2) Minimum 14-gauge (0.0800-inch) thickness sheet metal.
5. Frame:
   a. Material: G-90 galvanized steel.
   b. Fabricated from minimum 16-gauge metal sections.
   c. Metal sections joined to form a unitized assembly, for support of module internal components.
6. Joints:
   a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
   b. All seams caulked and sealed for an airtight unit.
   c. Fully through-bolted module to module joints sealed with bulb type gasketing on both mating modules.
7. Insulation:
   a. Double Wall Casing Units: Insulation fully encased between outside and inside panels. Units are double wall, unless noted otherwise.
   b. Properties:
      1) 1-inch thickness, 3 pounds per cubic foot density.
      2) Units with Perforated Liner:
         a) Black composite protective coating on surface exposed to airstream.
         b) Exposed insulation is not acceptable.
      3) Maximum effective thermal conductivity (C) of 0.24 Btu inch per square foot degrees F.
      4) Minimum NRC of 0.70 per inch thickness.
   c. Manufacturer: Carrier.
8. Access Doors:
   a. Heavy-gauge, oversized access doors insulated, double wall construction, internal sheet metal skin.
   b. Sized and located to provide easy access to unit internal components.
   c. Hinged, latched, and gasketed to provide a weatherproof seal.
   d. Provide doors on one side of each module.
   e. Latches:
      1) “Ventlok” style noncorrosive alloy latches operable from inside and outside of unit.
      2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to

partially open after first handle movement and fully open after second handle movement.

9. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.

C. Module Drain Pans:

1. Location: Inside each module, under each cooling coil and where indicated in these specifications.
2. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
3. Formed sections of minimum 16-gauge (0.0625-inch) Type 316 stainless steel.
4. Triple pitched for complete drainage, with no standing water in unit.
5. Double Wall Construction:
   a. Space between walls filled with foam insulation.
   b. Sealed moisture tight.
   c. Welded corners.
6. Drain Connections:
   a. Type 304 stainless steel, male pipe thread.
   b. Both ends of pan.
   c. Extended to exterior of unit cabinet.
   d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

D. Unit Base:

1. Full perimeter base frame.
2. Minimum 10-gauge (0.135-inch) structural steel construction, with C channel cross support members, on close centers.
3. Joints fully welded.
4. Fitted with lifting lugs at corner of unit or module.
5. Attached to unit at factory unless noted otherwise for field assembly.

E. Supply Fan Module:

1. General:
   a. Supply air module with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, lockable disconnect switch, drive assembly, support structure and accessories.
   b. Casing constructed in accordance with Paragraph Module Casing.
   c. Suitable to convey air at temperatures up to 250 degrees F.
   d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.

e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.

2. Fan Wheel:
   a. Centrifugal, one-piece, blade type as scheduled.
   b. Forward-Curved Fans:
      1) DWDI forward curved fan wheel.
      2) Shallow blades with inlet and tip curved forward in direction of airflow, metal construction, mechanically secured to backplate and inlet flange.
   c. Direct Drive Plenum Fans:
      1) Section shall have the option of one or more SWSI backward inclined air foil fan wheels.
      2) Nonoverloading performance characteristics.
      3) Backward inclined blades, hollow die-formed airfoil design, heavy-gauge metal construction, continuously welded to backplate and smooth curved inlet flange.
   d. Material: Type 316 stainless steel or aluminum.
   e. Attached to fan shaft with split taper lock bushing.
3. Fan Shaft, Bearings, Drive:
   a. Shafts:
      1) Turned, ground, and polished carbon steel.
      2) Ends drilled and countersunk for tachometer readings.
      3) Keyed for sheave installation.
      4) Coated with lubricating oil.
   b. Bearings:
      1) Grease lubricated, precision anti-friction ball, self-aligning type.
      2) Mounted in cast iron pillow block housing.
      3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   c. Drives:
      1) Factory set to specified fan revolutions per minute.
      2) Type: Direct.
      3) Arrangement: As required for dimensions scheduled and configuration of air handling unit as shown on the Drawings.
4. Internal Vibration Isolation:
   a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
   b. Flexible Connectors: Install flexible neoprene coated canvas duct between fan and unit casing to ensure complete isolation.

5. Accessories:
    a. Extended Lubrication Lines: For any bearing requiring lubrication, grease lines shall be extended to exterior of unit casing.
    b. Plenum Fan Guard Screen: Plenum-type fan module shall be provided with an expanded-metal guard screen for access door.

F. Refrigerant Coil Module:

1. General:
    a. Fin-tube direct expansion refrigerant cooling coil, complete with refrigerant controls, and related accessories.
    b. Casing constructed in accordance with Paragraph Module Casing.
    c. AHRI 410 performance rated and certified.
    d. Factory tested with air at 300 psig while immersed in an illuminated water tank.
    e. Designed and tested in accordance with ASHRAE 15.
    f. Coil shipped with end connections sealed and filled with a charge of dry nitrogen.
    g. Coils designed for use with refrigerant type in associated refrigerant compressor.
2. Coil Assembly:
    a. Refrigerant Piping Connections:
        1) On same side of module.
        2) Extended a minimum of 5 inches beyond the exterior of the unit casing, by the manufacturer.
    b. Coils removable from the unit at header end, unless shown otherwise on the Drawings.
    c. Clearly label liquid and suction headers on outside of module.
3. Refrigerant Circuiting:
    a. Dual Circuit as scheduled on the Drawings.
    b. Alternate tube circuited to distribute the cooling effect over the entire coil face at reduced load conditions.
    c. Refrigerant Distributors: Brass, replaceable nozzle type, connected to the coil by copper tubes.
4. Fins:
    a. Die-formed plate type, rippled for maximum heat transfer.
    b. Continuous metal across coil casing; split fins not acceptable.
    c. Shall have fully drawn collars and be mechanically bonded to tubes by mechanical expansion of tubes.
    d. Material: 0.0042-inch aluminum, sine wave.
    e. Fin density no greater than 12 fins per inch.
5. Tubes:
    a. Material: 1/2-inch OD by 0.016-inch wall seamless copper tubing.

b. Intermediate tube supports shall be supplied on coils over 44-inch fin length with an additional support every 42-inch multiple thereafter.

6. Headers:
   a. Located inside module.
   b. Constructed from seamless copper tubing with die formed tube holes and brazed joints.
   c. Refrigerant Piping Connections: Terminate with OD sweat copper.
7. Casing:
   a. Construct from minimum 16-gauge (0.0625-inch) G-90 galvanized steel.
   b. Formed end supports and top and bottom channels.
8. Drain Pan:
   a. Construction in accordance with Paragraph Module Drain Pans.
   b. Furnish drain pan under each cooling coil.
   c. Intermediate Drain Pan:
      1) Provide intermediate drain pans on all stacked cooling coils.
      2) Intermediate pan shall drain to main drain pan through a copper downspout.
9. Controls:
   a. Thermal Expansion Valve: Factory installed, with remote bulb field mounted.
10. Accessories:
    a. Coil Protective Coating:
       1) Provide factory applied corrosion protection coating on these coil components:
          a) Coil assembly, including exterior surfaces of fins and tubes.
          b) Refrigerant piping, headers, distributors, exposed to the air stream.
          c) Coil casings.
       2) Coating system type shall be factory dip-applied, in accordance with Article Coil Protective Coating.

G. Hydronic Coil Module:

1. General:
   a. Fin-tube hydronic coil, heating duty.
   b. Casing constructed in accordance with Paragraph Module Casing.
   c. Row count and fin density, as scheduled.
   d. 250-psi working pressure.
   e. AHRI 410 performance rated and certified.

2. Coil Assembly:
   a. Mounted on stainless steel support rack to permit coils to slide out individually from module.
   b. Water Supply and Return Connections:
      1) On same side of module.
      2) Extended a minimum of 5 inches beyond exterior of the unit casing, by manufacturer.
   c. Coils removable from the unit at header end, unless shown otherwise on the Drawings.
   d. Clearly label supply and return headers on outside of module.
   e. Arranged for counterflow between water and air; water shall enter coil on leaving air side of coil.
   f. Completely drainable.
   g. Factory tested with air at 300 psig while immersed in an illuminated water tank.
3. Fins:
   a. Die-formed plate type, rippled for maximum heat transfer.
   b. Continuous metal across coil casing; split fins not acceptable.
   c. Shall have fully drawn collars and be mechanically bonded to tubes by mechanical expansion of tubes.
   d. Material: 0.0075-inch corrugated waffle aluminum.
   e. Fin density no greater than 12 fins per inch.
4. Tubes:
   a. Material: 5/8-inch OD by 0.020-inch wall seamless copper tubing.
   b. Circuited to provide adequate tube velocities to meet design requirements.
   c. Internal turbulators are not acceptable.
   d. Pressure-equalizing baffles as required.
   e. Intermediate tube supports shall be supplied on coils over 44-inch fin length with an additional support every 42-inch multiple thereafter.
5. Headers:
   a. Located inside module.
   b. Constructed from seamless copper tubing with die formed tube holes and brazed joints.
   c. Water Supply and Return Connections:
      1) Schedule 40 red brass.
      2) Terminate with male pipe thread.
   d. Capped vent tapping at top of return header.
   e. Capped drain tapping at bottom of supply header.
   f. Completely drainable and cleanable.
6. Casing:
   a. Construct from minimum 16-gauge (0.0625-inch) G-90 galvanized steel.
   b. Formed end supports and top and bottom channels.

H. Access Module:

1. Access module to allow improved access to air handling internal components.
2. Casing constructed in accordance with Paragraph Module Casing.
3. Double wall, hinged, removable access doors on one side of module.
4. Minimum depth of 16 inches, larger where shown on the Drawings.

I. Filter Module:

1. General:
   a. Air filtration module, complete with filter media and filter racks.
   b. Casing constructed in accordance with Paragraph Module Casing.
   c. Double wall, hinged, removable access doors on one side of module.
   d. Maximum 350 fpm face velocity across filters.
2. Media Schedule: Disposable pleated type.
3. Media Construction:
   a. General:
      1) Contain in a rigid frame.
      2) Meet UL Class 2 standards.
      3) Rigid supporting mesh across the leaving face of media.
      4) Quality certified by ISO 9001.
   b. Preformed, Disposable Dry Extended Area Type: Rated at mean efficiency of 60 percent to 65 percent and average arrestance of 98 percent in accordance with ASHRAE 52.1, by ASHRAE Atmospheric Dust Test Method.
   c. Disposable Pleated Type:
      1) Pleated panel disposable filters.
      2) Nonwoven reinforced cotton/poly fabric media with a metal support grid and heavy duty beverage board-enclosing frame.
      3) 2-inch thickness.
      4) MERV 13 efficiency per ASHRAE 52.2.
      5) Minimum 30 percent dust spot efficiency and 90 percent average arrestance in accordance with ASHRAE 52.1.
4. Frame and Filter Assembly:
   a. Suitable for space indicated.
   b. Permanent re-usable, side-loading 16-gauge (0.0625-inch) steel holding frame, retainer, and sealer frame.
   c. Filter blank-offs to prevent air bypass around filters, same material as frame.
5. Manufacturers:
   a. Farr.
   b. Flanders.

c. Tri-Dim.
d. American Air Filter.

J. Mixing Module:

1. General: Mixing and control of up to 80 percent return air and 20 percent outside air streams.
2. Include control dampers on return, exhaust, and outside air inlets.
3. Position dampers blades across short dimension of each air opening.
4. Linkages arranged so corresponding outside and return air dampers move together.
5. Install damper linkage at factory to provide minimum and maximum damper segments proportional to required quantities of minimum and maximum outside air.

K. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 16, Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.
3. Main Control Panel:
   a. Provide unit main control panel, with all electrical and control components housed in a single enclosure.
   b. NEMA Type 1 enclosure.
   c. Factory-mounted on exterior of unit casing, located on unit side.
   d. Same material/finish as unit casing.
   e. Adequate spare space for field installation of additional electrical and control components.
   f. Access Doors: Hinged, latched, and gasketed to provide a weatherproof seal.
4. Factory Installed Disconnects:
   a. Provide main electric power disconnect for unit.
   b. Provide electric power lockable disconnect for each module containing electrical components.
   c. NEMA Type 3R enclosure.

d. Nonfused type.
e. Factory installed on outside of fan module cabinet, and factory wired to electrical component terminals.

5. Electrical Convenience Outlets:
   a. Duplex type, 120V, factory installed and wired.
   b. Location:
      1) On exterior of unit, next to each fan section access door.
      2) Inside unit Main Control Panel.

L. Accessories:

1. Provide where scheduled in Equipment Schedule and as follows:
   a. Corrosion Protection Coating:
      1) Provide factory applied corrosion protection coating on these unit components:
         a) Fan wheel (or propeller).
         b) Fan housing.
         c) Fan accessories.
         d) Interior surfaces in contact with air stream.
         e) Exterior cabinet.
      2) Coating system shall be as scheduled in Equipment Schedule and shall be in accordance with Paragraph Corrosion Protection Coating.

M. Manufacturers and Products:

1. Carrier; 39MW.
2. Trane; Climate Changer, Series M.
3. York.

2.07 MOTORS

A. General:

1. Fan motors shall comply with provisions of Division 16, Electrical, Specifications.
2. Provide integral manual reset or self-resetting overload protection on single-phase motors. Provide IEEE 841 motor, unless noted otherwise.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Fan motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows unless designated otherwise on fan equipment schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.

2.08 CORROSION PROTECTION

A. General:

1. Factory applied corrosion protection coating for application to unit components and accessories, where in required by this section.
2. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning:
   a. For all coating systems, parts to be coated shall be cleaned as follows:
      1) Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
      2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.
      3) Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Polyester:

1. Material: Polyester.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
   a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.

b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
d. Pencil Hardness: 2H, ASTM D3363 test method.
e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
f. Service Temperature: Maximum 230 degrees F, continuous.

C. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
   a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
   b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
   c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
   d. Pencil Hardness: 2H, ASTM D3363 test method.
   e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
   f. Service Temperature: Maximum 230 degrees F, continuous.

2.09 COIL PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable. If protective coating is applied to coil after factory assembly of equipment, cost for shipping unit to coating factory, disassembly, coating process, reassembly, and delivery to Site shall be borne by Contractor.

B. Coating Material:

1. Use one of the following materials:
   a. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
   b. Epoxy or epoxy-urethane.
   c. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Coil shall be completely removed from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

D. Performance:

1. Coil finish shall meet or exceed the following criteria:
   a. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
   b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
   c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.
3. Bronzglow; Husky® Coil Coat (HLF 815C659).

2.10 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests and Adjustments: Test equipment actually identical to that furnished.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Manufacturer’s Tests:

1. Water Coil Test: No leaks when tested underwater with 200 psi air.
2. DX Coil Test: Leak tested under water with 300 psi air.
3. Electrical Circuits:
    a. Tested and checked as to proper function.
    b. Perform dielectric strength test.
4. Air Handling Unit Cabinet Tests:
    a. Air Pressure Leak Testing: For modules under positive pressure located on discharge side of a fan, maximum permissible air leakage shall not exceed 1 percent of specified airflow, when subject to 8-inch water gauge differential pressure.
    b. Panel Deflection Testing: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch water gauge differential pressure.

c. Leakage Test Failure Guarantee: Upon completion of leakage test, if unit does not meet specified performance for deflection or leakage, Owner may elect to have unit modified to meet specified performance or may request a credit according to performance failure.

D. Balancing:

1. Completed fan assemblies shall be dynamically balanced to minimum grade of G 6.3 per AMCA 204 at design operating speed.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design RPM.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.

C. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

D. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

E. All condensate drain connections piped and trapped separately for proper drainage.

F. Labeling: In accordance with Article Accessories.

G. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

H. Equipment Restraints:

1. Restrain equipment against seismic forces as required by Code.
2. Restrain equipment against wind loads as required by Code.
3. Seismic Restraint Snubbers:
   a. Rubber-faced, securely anchored to floor or structure.
   b. Install with sufficient clearance so unit isolators are not restricted for proper free isolation but do limit movement in all directions.

I. Connections:

1. Isolate sheet metal duct connections from all noninternally spring-isolated fan units or other rotating equipment.
2. Install ductwork adjacent to fans to allow proper service and maintenance.
3. Pipe drain pan connection through trap running to floor drain.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify shipping blocking and bracing are removed.
2. Verify unit is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully OPEN position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated rpm.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Lubricate non-sealed bearings prior to startup.

C. Air Balancing:

1. Perform air system balancing as specified in Section 15950, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

3.04 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01640, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 2 person-days for prestartup classroom or Site training.
   d. 2 person-days for facility startup.
   e. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

C. Refer Section 01640, Manufacturers' Services and Training.

END OF SECTION

SECTION 15730
UNITARY AIR-CONDITIONING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. Air Moving and Conditioning Association (AMCA): Bulletin 300, Setup No. 1.
3. American Gas Association (AGA).
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
5. American Society of Mechanical Engineers (ASME): BPVC Section IX, Welding and Brazing Qualifications.
6. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2370, Standard Test Method for Tensile Properties of Organic Coatings.
   c. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   e. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
7. Canadian Standards Association (CSA).
8. ETL Testing Laboratories (ETL).
9. International Organization for Standardization (ISO):
   a. 9001, Quality Management Systems - Requirements.
   b. 13256-1, Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps.
10. National Electrical Manufacturers Association (NEMA).

11. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
12. UL: 94, Safety Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Air Conditioning.
2. COP: Coefficient of Performance.
3. DX: Direct Expansion.
4. EER: Energy Efficiency Ratio.
5. HP: Heat Pump.
6. IR: Infra Red.
7. LED: Light Emitting Diode.
8. PSC: Permanent Split Capacitor.
9. PTAC: Packaged Terminal Air Conditioner.
10. SPST: Single Pole, Single Throw.
11. TXV: Thermostatic Expansion Valve.
12. UV: Ultraviolet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Seismic anchorage and bracing drawings and data sheets, as required by Section 01612, Anchorage and Bracing.
   b. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for all products specified.
   c. Manufacturer’s standard finish color selection for enclosure finishes.
   d. Complete performance data that will indicate full compliance with specification:
      1) Include fan sound power level data (ref. 10 watts to 12 watts) at design operating point, based on AMCA Bulletin 300, Setup No. 1.
      2) Include heating and cooling performance data at design operating conditions.
   e. Factory dip-applied protective coating product data.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Manufacturer's documentation that media filter modules rated UL Class 1.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01600, Product Requirements, for heat pumps, air-conditioning units, and motors.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
5. Sample copy of guarantee.
6. Test reports.
7. Operation and Maintenance Data in conformance with Section 01782, Operation and Maintenance Data.
    a. Include wiring and control diagrams for equipment.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1.

B. Unit shall be rated (when matched with appropriate outdoor unit) per AHRI 210/240.

C. Units shall be certified by UL and CSA and shall be UL or ETL listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

B. Protection of Equipment:

1. Box, crate, or otherwise protect from damage and moisture during shipment, handling, and storage.
2. Protect from exposure to corrosive fumes and keep thoroughly dry at all times.

3. Store motors, drives, electrical equipment, and other equipment with antifriction or sleeve bearings in weathertight and heated storage facilities prior to installation.
4. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

1.06 SPECIAL GUARANTEE

A. Refrigerant Compressors: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of compressors specified in this specification found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.07 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Delivery: In accordance with Section 01600, Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Specified components of this section, including insulation, facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Multiple Compressor Units:

1. Provide completely independent refrigeration circuits and controls.
2. Indoor unit air coils shall have intermingled circuits, unless specified otherwise.

2.02 EQUIPMENT SCHEDULES

A. Refer to the Drawings.

2.03 SPLIT SYSTEM AC OUTDOOR UNITS

A. General:

1. Factory assembled, single piece, air-cooled air conditioner outdoor unit.
2. Contained within the unit enclosure shall be factory wiring, piping, controls, compressor, and holding charge of R-410A refrigerant.
3. Fully charged with R-410A refrigerant and oil or with nitrogen holding charge.
4. Outdoor unit shall be same manufacturer as associated indoor unit.
5. Ambient operating temperature up to 120 degrees F.
6. Sound rating maximum of 53 db(A).

B. Unit Cabinet:

1. Constructed of galvanized steel, phosphatized and coated with a baked enamel finish. Finish shall pass the 500-hour salt spray test.
2. Removable access panels for access to internal components.
3. Outdoor Compartment: Isolated, with acoustic lining to ensure quiet operation.
4. Knockouts for unit electrical power.

C. Condenser Fans:

1. Direct-drive propeller type shall discharge air vertically and shall blow air through outdoor coil.
2. Motors:
   a. Totally enclosed, with Class B insulation and permanently lubricated bearings.
   b. Thermal overload protection.
3. Shaft of galvanized or stainless-steel construction.
4. Fan blades shall be steel, corrosion-resistant and be statically and dynamically balanced.
5. Equip openings with PVC-coated protection grille over fan and coil.

D. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.
3. Internal overloads shall protect compressor from overtemperature and overcurrent.
4. Motor: NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Scroll compressors shall have high discharge gas temperature protection.

6. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
7. Factory installed liquid line dryer.
8. Installed on rubber vibration isolators and shall have internal spring isolation.

E. Condenser Coil:

1. Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes that are cleaned, dehydrated, and sealed.
2. Coat entire coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

F. Refrigeration Components:

1. Brass external liquid line service valve with service gauge port connections.
2. Liquid and suction lines service valves, capped.
3. Suction line service valve with service gauge connection port.
4. Service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps.
5. Suction Line: Accumulator.
6. Pressure relief.

G. Controls:

1. Microprocessor based controls, all factory wired with colored and keyed connectors and color-coded wires indicating fault diagnostics with LED indicator.
2. Terminal strip for 24V control terminations with a control transformer.
3. Factory selected, assembled, and tested.
4. Refrigerant Metering:
   a. Reversing valve for heat pump units.
   b. Heating mode metering device for heat pump units.
5. Automatic restart on power failure.
6. Three-pole contactors.
7. Time delay control sequence shall be provided standard through control board on indoor units.
8. High pressure and liquid line low pressure cutout switches.
9. Automatic outdoor fan motor protection.
10. Hard start kit.
11. Anti-short circuit timer.

12. Manual reset high pressure safety switch.
13. Start capacitor and relay (single-phase units without scroll compressors).
14. Defrost board to provide defrost control.
15. Safeties:
    a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
    b. Safety lockout if an outdoor unit safety is OPEN.
    c. High condensing temperature protection.
    d. System diagnostics.
    e. Compressor motor current and temperature overload protection.
    f. High pressure relief.
    g. Outdoor fan failure protection.

H. Accessories:

1. Provide as scheduled in Equipment Schedule and as follows:
    a. Low-Ambient Cooling Kit:
        1) Solid state condenser fan motor fully modulating speed cycling controller; responds to saturated condensing pressure/temperature of unit.
        2) Maintains a saturated condensing temperature of 100 degrees F plus or minus 10 degrees F with outdoor temperatures down to minus 20 degrees F.
        3) Includes winter start control package, to bypass low-pressure switch temporarily to allow compressor start during low load conditions.
        4) Includes ball bearing condenser fan motor.
    b. Compressor Cycle Delay: Compressor prevented from restarting for a minimum of 5 minutes after shutdown.
    c. Hot Gas Bypass: Cooling capacity modulation with hot-gas solenoid valve and bypass piping on lead compressor.
    d. Compressor Start Assist: Capacitor/relay type.
    e. Evaporator Freeze Thermostat: SPST temperature activated switch, shuts down unit upon evaporator freeze-up.
    f. Filter Drier: Liquid-line mounted, bi-flow type for heat pumps.
    g. Liquid Solenoid Valve: Electric operated shutoff valve, bi-flow for heat pumps, interlocked with compressor operation.

I. Manufacturers:

1. Carrier.
2. Trane.
3. Rheem.

4. Lennox International.
5. Addison.
6. Mitsubishi.
7. York Air Conditioning.

2.04 UNITARY EQUIPMENT CONTROLS

A. Electric Thermostat:

1. Two-position electric type.
2. Temperature Scale: Furnish 50 degrees F to 90 degrees F scale.
3. Adjustments external to units.
4. Adjustable sensitivity.
5. Nonlocking cover.
6. Insulating back, where exterior mounting is indicated.

B. Direct Digital Control: Stand-alone control module compatible with temperature control system.

2.05 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable. If protective coating is applied to coil after factory assembly of equipment, cost for shipping unit to coating factory, disassembly, coating process, reassembly, and delivery to Site shall be borne by Contractor.

B. Coating Material:

1. Use one of the following materials:
   a. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
   b. Epoxy or epoxy urethane.
   c. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes, repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Completed remove coil from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks, and blisters.

D. Performance:

1. Coil finish shall meet or exceed the following criteria:
   a. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
   b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
   c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.

2.06 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters or Contactors: Factory installed with unitary equipment, unless otherwise noted.
4. Single power connection.

5. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 16222, Low Voltage Motors Up to 500 Horsepower, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer's standard.
   e. Space Heater: Manufacturer's standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer's standard.
   g. Efficiency: Minimum efficiency per Section 16222, Low Voltage Motors Up to 500 Horsepower.

2.07 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved die-stamped block type black enamel filled equipment identification number and letters indicated in this specification.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications. Quantity as recommended by manufacturer.

2.08 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-pounds per square gauge air. Pressure tested to 450 pounds per square gauge.
2. Electric heating coils tested with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with manufacturer’s recommendations, and these specifications.
2. Set and install equipment so equipment is level and properly supported.
3. Ensure piping connections to equipment do not cause strain on equipment.
4. Ensure vibration isolation has been installed per manufacturer’s instructions and isolation devices are performing satisfactorily.
5. Install safety devices as recommended by manufacturer and required by code.

B. Isolate sheet metal duct connections from portions of unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

C. Inspect internal casing insulation, seal exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. Filters:

1. Install set of filters in each unit before operating and leave in place during startup and testing to keep equipment and ductwork clean.
2. Do not operate units until filters are installed. If operated without filters, completely clean ductwork, coils, and interior of units.

E. Lubricate unsealed bearings prior to startup.

3.02 FIELD QUALITY CONTROL

A. Initial equipment testing and startup shall be made by authorized representative of unit manufacturer.

B. Air-cooled outdoor unit shall not be started without complete prestart checkout of entire refrigerant piping system and charging of system with refrigerant as recommended by equipment manufacturer.

C. Field Testing: Manufacturer shall provide factory-trained representative employed by equipment manufacturer to perform the following services. Supervision only, of Contractor personnel, will not be acceptable.

1. Leak test.
2. Refrigerant pressure test.
3. Evacuate (if required).
4. Dehydrate (if required).
5. Charge condensing unit with refrigerant and oil (if required).

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01640, Manufacturers' Services and Training, for the following:

1. Inspect installation including external interlock, power connections; supervise initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.
2. Test Report:
   a. Submit test reports unit is in safe and proper operating condition.
   b. Contain pressure and control settings, meg readings, voltage readings per phase during START and RUN, suction temperature and pressure, liquid temperature and pressure.
   c. List minor discrepancies to be corrected which do not affect safe and reliable operation.
   d. One copy of report shall be left in unit control panel.
3. One copy of bound installation operation and maintenance service, and parts brochures, including applicable serial numbers, full unit description, parts ordering sources, shall be placed in unit control panel at time of starting.
4. Training of Owner's personnel for specified equipment.

3.04 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 15950, Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 15810
METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
   c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
   e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
   g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
   h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
   j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.

k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened and Bake Hardenable.
l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fibrous Glass Duct Construction Standards.

d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
e. HVAC Air Duct Leakage Test Manual.

9. UL:
   a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
   b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
   c. 555, Standard for Safety Fire Dampers.
   d. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute.
2. FPM: feet per minute.
3. PCF: pounds per cubic foot.
4. WC: water column.

B. Sealing Requirements:

1. For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:
   a. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
   b. Joints, duct surface connections including:
      1) Girth joints.
      2) Branch and subbranch intersections.
      3) Duct collar tap-ins.
      4) Fitting subsections.
      5) Louver and air terminal connections to ducts.
      6) Access door, and access panel frames and jambs.
      7) Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Rectangular, Rigid Round Ductwork:
      1) Schedules of duct systems, materials, joints, sealing, gauge and reinforcement.
      2) SMACNA Figure Numbers for each shop fabricated item.
      3) Reinforcing details and spacing.

4) Seam and joint construction details.
5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

b. Ductwork Accessories:
1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
a) Fittings and volume control damper installation (both manual and automatic) details.
b) Duct liner.
c) Sealing materials.
d) Dampers: Include leakage, pressure drop, and maximum back pressure data.
e) Duct-mounted access panels and doors.
f) Flexible ducts.
g) Sheet metal fasteners.

2. Duct Fabrication Drawings:
a. Drawn after actual job measurements are obtained.
b. Drawn to a scale not smaller than 1/4-inch equals 1-foot, on drawing sheets same size as the Drawings.
c. Include the following features:
1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
2) Duct layout, indicating pressure classifications, and sizes in plan view.
3) Duct material and thickness.
4) Fittings and volume control damper installation (both manual and automatic) details.
5) Reinforcing details and spacing.
6) Seam and joint construction details.
7) Penetrations through fire-rated and other partitions.
8) Duct accessories and control devices such as automatic dampers, airflow monitors, terminal units, smoke detectors, regulators, air distribution devices, etc.
9) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
10) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installation.
11) Coordination with ceiling suspension members.
12) Spatial coordination with other systems installed in same space with duct systems.

13) Coordination of ceiling- and wall-mounted access doors and panels required for access to dampers and other operating devices.
14) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
15) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment.

3. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01612, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01451, Special Inspection, Observation, and Testing.
3. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Engineer.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork

B. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

C. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

D. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Article Supplement.

2.02 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions and shall be increased in both dimensions by twice the thickness of the liner.

C. Ductwork thinner than 26-gauge will not be allowed.

D. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and joints shall be external.
4. For ductwork that is required to be reinforced, use only external reinforcing.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from galvanized steel.

B. Where no specific ductwork materials are indicated in these Specifications or on the Drawings, galvanized steel sheet metal shall be basis of Contract.

C. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.
2. Product Name: Steel sheet zinc-coated (galvanized steel).
3. Sheet Designation: CS Type B.
4. Applicable Specification: ASTM A653/A653M.
5. (Zinc) Coating Designation: G90.
6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
8. Provide sheet metal packaged and marked as specified in ASTM A700.

D. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
3. Gauge shall comply with SMACNA manual, unless specified otherwise.
4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.
5. With No. 4 finish on exposed surface for ducts exposed to view.

E. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

F. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Water-Based Sealants:

1. Listed by manufacturer as nonflammable in wet and dry state.
2. Manufacturers and Products:
   a. Foster; Series 32.
   b. Childers; CP-145A, 146.
   c. Rectorseal; Airlok 181.

2.05 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
2. Stainless Steel Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.

2.06 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated as follows:

1. Supply Ducts: 3-inch WC.
2. Return Ducts: 2-inch WC, negative pressure.
3. Exhaust Ducts: 2-inch WC, negative pressure.

B. Where no specific duct pressure designations are indicated in these Specifications or on the Drawings, 2-inch WC pressure class shall be basis of Contract.

2.07 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

C. Air Handling Unit Discharge Ductwork: Ductwork extending from variable air volume air handling units up to and including first elbow or terminal tap outside air handling unit room shall be constructed of 16-gauge, minimum sheet metal, same material as remainder of system.

2.08 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
5. Manufacturers and Products:
   a. Elgen; All-Tight.
   b. Duro-Dyne; Type TR.

2.09 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections or with factory fabricated, field installed taps, with spin-in or mechanical fastened tap to main duct connections. Field installed taps are not acceptable.

2.10 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Basic Round Diameter: As used in this article, is inside diameter of size of round duct.

C. Where space limitations prevent use of round duct or where shown on the Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.11 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.

B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two-piece segment elbows are not allowed, except with turning vanes.
2. Segmented Elbows: Fabricate with welded construction.
3. Round Elbows 8 Inches and Smaller:
   a. Stamped elbows for 45-degree and 90-degree elbows and pleated elbows for 30 degrees, 45 degrees, 60 degrees, and 90 degrees configuration.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.
4. Round Elbows 9 Inches Through 14 Inches:
   a. Segmented or pleated elbows for 30 degrees, 45 degrees, 60 degrees, and 90 degrees.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.12 ROUND DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

B. Field installed taps are not acceptable.

2.13 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Duct hanging system shall be composed of three elements: upper attachment to building, hanger itself, and lower attachment to duct.
3. Wire hangers are not acceptable.
4. Hanger Spacing:
   a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.
   b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials:

1. Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
   a. Galvanized Steel Ductwork:
      1) Indoors: Carbon steel, zinc electroplated.
      2) Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
   b. Stainless Steel Ductwork Indoors and Outdoors: Stainless steel, same ASTM Grade as ductwork.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
3. Upper Attachment (Concrete):
   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
   c. Concrete attachments shall be made of steel.

D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.14 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and NFPA 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
   a. Comply with NFPA 701 or UL 214 (except Teflon coated).
   b. Woven polyester or nylon for most applications.
   c. Woven fiberglass for high temperature applications.
   d. Coating: Vinyl.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch wide sheet metal.
3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch wide sheet metal.
4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

2.15 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less than 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

1. Size: 18-inch and 24-inch diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.

2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturer and Product: Flexmaster; Inspector Series.

C. Casing and Plenum Access Doors:

1. Size: 57 inches high by 24 inches wide minimum where possible.
2. Complete with hardware, hinges, seals, and latch handles.
3. Doors and frames shall be designed to close with pressure.
4. Latch Handles: Ventlock, Series No. 260.
5. Hinges: Ventlock, Series No. 200 and No. 300.

D. Manufacturers:

1. Ventlok.
2. Duro-Dyne.
3. Flexmaster.

2.16 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.
4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers:
   a. Accessible Ductwork: Ventlok; Type 620 or 635.
   b. Accessible Insulated Ductwork: Ventlok; Type 639.
   c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.

B. Manual Opposed-Blade Balancing Dampers:

1. Externally operated gang airfoil, damper blades.
2. Fabricate from same material as ductwork.
3. Stainless steel or nylon sleeve bearings.
4. Construction shall have interlocking edges and maximum 10-inch blade width.
5. Manufacturers and Products:
   a. Ruskin; CD102.
   b. American Warming and Ventilating; Model VC-31.

2.17 EXTERNAL DUCT INSULATION

A. Refer to Section 15905, HVAC Insulation.

2.18 MISCELLANEOUS ACCESSORIES

A. Louver and Grille Blank-off Sections:

1. Fabricate from 20-gauge sheets of same material as louver/grille.
2. Line with sound attenuation/insulating material.
3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

B. Auxiliary Drain Pans:

1. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.
2. Construction: 16-gauge stainless steel with welded joints. Pans shall be watertight and have hemmed edges.
3. Drain Connection:
   a. Minimum 1-inch IPS or as shown on the Drawings.
   b. Locate at lowest point of drain pan.
   c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

C. Prefabricated Curb Adapter:

1. Minimum of 14-gauge galvanized steel with fully welded corners.
2. Provide 1-inch duct liner insulation on all air-impacted surfaces.
3. Manufacturer: Thycurb.

D. Accessories Hardware:

1. Instrument Test Holes:
   a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
   b. Size to allow insertion of pitot tube and other testing instruments.
   c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
   a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
   b. Provide in sizes from 3 inches to 18 inches to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

2.19 DUCTWORK IDENTIFICATION

A. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch high letters for ductwork and not less than 3/4-inch high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

B. Plastic Duct Markers:

1. General:
   a. Provide manufacturer’s standard laminated plastic, color coded duct markers. Conform to the following color code:
      1) Black Text on Yellow Background: Odorous Air.
      2) White text on blue background.
      3) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.

C. Nomenclature:

1. Include the following:
   a. Direction of air flow.
   b. Duct service (supply, return, exhaust).
   c. Duct origin (from).
   d. Duct destination (to).
   e. Design cfm.

D. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.

b. Fit collars snugly around ducts and insulation.
c. Same gauge and material as duct.
d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
e. Use fasteners with maximum 6-inch centers on collars.

4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.
3. Limit clearance to 1-inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on the Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.

3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
   a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
   b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance with the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
   c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
   d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
   e. Conform to SMACNA Class A sealing requirements.

3.03 RIGID ROUND DUCTWORK

A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.

B. Rigid Round Ductwork Joints:

1. Rigid round ductwork joints shall be in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.

2. Single and Double Wall Supply and Return System Joints:
   a. Less than 36 Inches: Slip coupling.
   b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
3. Single and Double Wall Exhaust and Return System Joints:
   a. Spiral Seam Duct: Welded flanged connector.
   b. Longitudinal Seam Duct: Van Stone flange connector.

3.04 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

H. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

3.05 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.06 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jackshaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on the Drawings in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.07 ACCESS DOORS

A. Ductwork:

1. Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
   a. Motorized damper.
   b. Volume damper.

3.08 EXTERNAL DUCT INSULATION

A. Refer to Section 15905, HVAC Insulation.

3.09 MISCELLANEOUS ACCESSORIES

A. Louver and Grille Blank-off Sections: Attach airtight to louver and install to allow for easy removal.

B. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

3.10 DUCT SEALING

A. Seal duct seams and joints as follows:

1. In accordance with SMACNA requirements.
2. In accordance with the following:
   a. Pressure Classifications Greater than 3-Inch WC: Transverse joints, longitudinal seams, and duct penetrations.
   b. Pressure Classification Between 2-Inch and 3-Inch WC: Transverse joints and longitudinal seams.
   c. Pressure Classification Less than 2-Inch WC: Transverse joints only.
3. In addition to other requirements, provide the following duct sealing:
   a. For interior ductwork, tape joints with Hardcast Lag-Rite tape and bonder or Ray-Chem shrink tape.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Seal all audible leaks.

3.11 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 15950, Testing, Adjusting, and Balancing for HVAC.

3.12 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects, and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.13 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

3.14 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Ductwork Schedule.

END OF SECTION

DUCTWORK SCHEDULE

SYSTEM	SERVICE	SECTION	SMACNA DUCT CONSTRUCTION CRITERIA			APPLICABLE REMARKS
			PRESSURE CLASS (IN W.G.)	MATERIALS OF CONSTRUCTION	SEAL CLASS	
725AHU5001	SUPPLY AIR	ALL	2	GALVANIZED STEEL	A	A, B, C
AIR HANDLER	OUTDOOR AIR	ALL	-2	GALVANIZED STEEL	A	A, B, C
CONSTANT AIR VOLUME	RETURN AIR	ALL	-2	GALVANIZED STEEL	A	A, B, C

REMARKS:

A: REFER TO AREA CLASSIFICATION AND MATERIALS SELECTION TABLE IN THE GENERAL SECTION OF DRAWINGS.

B: CONSTRUCT DUCT SYSTEMS TO PRESSURE CLASSIFICATION NOT LESS THAN THE HVAC EQUIPMENT MANUFACTURER'S CALCULATED TOTAL STATIC PRESSURE (TSP) OF EACH FAN SYSTEM PRESSURIZING THE DUCTWORK. TSP VALUES FOR SELECTING THE PRESSURE CLASS TO MATCH THE TSPS SUBMITTED UNDER SECTION 23 81 00, UNITARY AIR-CONDITIONING EQUIPMENT.

C: REFER TO SPEC SECTION 15905 FOR DUCT INSULATION REQUIREMENTS.

SECTION 15850
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to the Drawings.

2.02 CEILING DIFFUSERS

A. Adjustable Round Face Diffusers (CD6):

1. Construction: Refer to Equipment Schedule.
   a. Finish: Baked white enamel face finish.
   b. Neck: Round.
2. 360-degree discharge pattern.
3. Fully adjustable throw from horizontal to vertical, from face of diffuser, by rotation of center cone.
4. Three removable center cones for duct maintenance access.
5. Continuous sponge rubber gasket at face flange.
6. Performance: Refer to Equipment Schedule.
7. Manufacturers and Products:
   a. Krueger; Model RA2 (steel).
   b. Carnes; Type SSAA (steel).
   c. Titus; Model TMRA-AA.

2.03 RETURN GRILLES

A. Louvered Return, Exhaust and Transfer Grilles (RG1):

1. Construction: Refer to Equipment Schedule.
   a. Finish: Baked white enamel face finish.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.
4. Manufacturers and Products:
   a. Krueger; S80/S580H Series.
   b. Carnes; Type RAAAH.
   c. Titus; 350 Series.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install diffusers, grilles tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

B. Provide appropriate frame to adapt to mounting surface.

END OF SECTION

SECTION 15900
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. Handbook Fundamentals.
   b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
   c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
   a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Federal Communications Commission (FCC).
7. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. UL: 916, Standard for Safety Energy Management Equipment.

1.02 DEFINITIONS

A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.

B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.

C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).

D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.

E. Control Wiring:

1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats, PE and EP switches and like devices.
3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.

F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.

G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 72 degrees F to 78 degrees F; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.

H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.

I. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.

J. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. BAS: Building Automation System.
4. CHWS/R: Chilled/Hot Water Supply/Return.
5. CMOS: Complementary Metal Oxide Semiconductor.
6. DDC: Direct Digital Control.
7. DX: Direct Expansion.
8. EEPROM: Electronic Erasable Programmable Read Only Memory.
9. EMCS: Environmental Management and Control System.
10. HCP: HVAC Control Panel.
11. HGS/R: Hot Glycol Supply/Return.
12. HMI: Human-Machine Interface.
13. HOA: Hand-Off-Auto (Switch).
14. HVAC: Heating, Ventilation, and Air Conditioning.
15. IP: Current (I) - Pressure (P), as in IP transducer.
16. LCD: Liquid Crystal Display.
17. LED: Light Emitting Diode.
18. PLC: Programmable Logic Controller.
19. RAM: Random Access Memory.
20. RTD: Resistance Temperature Detectors.
21. VAV: Variable Air Volume.
22. W3: Nonpotable Water.

1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring, and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
5. Provide sequences and functions as required to deliver a fully functioning HVAC system.

B. Control System Types:

1. The following control system types may be used in this Project:
   a. Electric/Electronic Control System (ELECTRIC):
      1) System using simple electric or electronic control devices.
      2) User interface at control device.
   b. Standalone DDC Control System (STANDALONE DDC):
      1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
      2) No information sharing between controllers.
      3) User interface at DDC controller.
      4) Refer to Section 15902, Direct-Digital Control System for HVAC, for additional requirements.
   c. Networked DDC Control System (NETWORKED DDC):
      1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
      2) Information within control system can be utilized by any control component over high-speed network.
      3) User interface via computer workstation and/or portable terminal.
      4) Refer to Section 15902, Direct-Digital Control System for HVAC, for additional requirements.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Type Schedule		
Location	**System**	**Control Type**
Process Areas	All	STANDALONE DDC

C. Performance Requirements:

1. Design control system and equipment to perform under the following conditions:
   a. Temperature, Ambient:
      1) Summer Maximum: 88.5 DB/66.5 WB degrees F.
      2) Winter Minimum: 28.2 DB degrees F.
      3) Based on ASHRAE Handbook fundamentals weather data for the City of Aurora.

b. Temperature, Indoor:
1) Air-conditioned Non-process Areas:
a) Summer Maximum: 75 degrees F.
b) Winter Minimum: 70 degrees F.

D. Performance requirements.

1.04 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list.
6. Interfaces with HVAC equipment.
a. Schematic diagram of each equipment item.
b. Indicate location of each control item in equipment.
c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.

B. Informational Submittals:

1. Table identifying which member of Contractor’s team is responsible for furnishing and setting in-place power wiring and control wiring of each item or component of HVAC equipment.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer’s Certificate of Compliance, in accordance with Section 01600, Product Requirements.
4. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01640, Manufacturers’ Services and Training.
5. Draft maintenance agreement.
6. Confirmation that control system Supplier has received and coordinated with all approved HVAC equipment submittals.
7. Experience and qualifications of control system Supplier’s proposed representative who will supervise installation, adjustment, and calibration of control systems.

8. Performance test plan and schedule.
9. Test Results:
    a. Functional and performance test documentation.
    b. Component calibration sheets for each instrument and panel component as described in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
10. Operation and Maintenance Data:
    a. In accordance with Section 01782, Operation and Maintenance Data. In addition, include the following detailed information:
        1) Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
        2) Record of system adjustments and calibration methods.
        3) Performance test results.

1.05 QUALITY ASSURANCE

A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of UL.

B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.

1. UL: Products shall be UL 916-PAZX listed.
2. National Electrical Code NFPA 70.
3. Federal Communications Commission Part J.

C. Qualifications of HVAC Controls System Supplier:

1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.
5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.

6. Necessary facilities to provide Owner with complete maintenance, periodic inspection, and service contract.

D. FCC Regulation: Electronic equipment shall conform to requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
   a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.
   b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01600, Product Requirements.

B. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.
2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer’s recommendations.

1.07 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Special tools required to maintain or dismantle.	One complete set for each different size unit.

1. Spare parts shall be available for at least 5 years after Substantial Completion.

C. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified shall be products of the following manufacturers, unless indicated otherwise:

1. Allen Bradley.
2. Siemens Building Technologies.
3. Johnson Controls.
4. The Trane Company.
5. Honeywell.
6. Invensys.
7. Alerton Technologies.
8. Delta Controls.
9. Automated Logic Corporation.
10. Andover.

2.02 MATERIALS

A. General:

1. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
2. System shall not be used as test Site for new products, unless explicitly approved by Owner’s representative, in writing.

B. Control Components:

1. Control range to obtain specified capacities.
2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.

C. Controls Interfacing:

1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
3. Coordinate interfaces with electrical work as necessary.
4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

A. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of UL and Factory Mutual (FM).

B. Valid label affixed to item shall provide indication of product acceptance by required agencies.

C. HVAC control panels and control components that consist of multiple components shall bear UL listing mark on unit.

2.04 SERVICE CONDITIONS

A. Refer to Section 01600, Product Requirements, and Electrical Drawings for classification of areas as hazardous, corrosive, wet, indoor dry, and dust-tight.

B. Use materials and methods, and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.

C. Exhaust ductwork shall be considered same classification as area served.

D. Instruments within 3 feet of ducts conveying air from spaces classified as Class I, Division 1 or Division 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Electrical components shall be provided in accordance with requirements of Division 26, Electrical.

B. Wiring:

1. In accordance with NFPA 70.
2. Insulation shall be rated 600 volts, minimum.

C. Electrical Raceways: In accordance with NFPA 70.

2.06 FIELD COMPONENTS AND INSTRUMENTS

A. Refer to HVAC controls detailed specification, Section 15901, HVAC Controls, Field Components, and Instruments.

2.07 MICROELECTRONIC CONTROL COMPONENTS

A. Refer to HVAC controls detailed specification, Section 15902, Direct-Digital Control System for HVAC.

2.08 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates:

1. Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification.
2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
    a. Night low limit thermostats.
    b. Manual override timers.
    c. START/STOP switches.
    d. Humidistats.
    e. Emergency STOP switches.

f. Special purpose devices.
g. HVAC control panels.

C. Anchor Bolts: Galvanized, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05500, Metal Fabrications. Coat in accordance with Section 09900, Painting and Coating.

2.09 EQUIPMENT FINISH

A. Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated.

B. If manufacturer has no standard color, provide gray finish as approved by Owner.

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference the Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Engineer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Wiring:

1. General:
   a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
   b. Install control and interlock wiring separate from power wiring.
   c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
   d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.

e. Restrain wiring in control panels by plastic ties or ducts.
f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.
i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
j. Properly support and run wiring in a neat manner.
k. Run wiring parallel or at right angles to building structure.

2. Concealment:
   a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
   b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
   c. Install exposed and concealed low voltage control wiring systems in conduit.
   d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
   e. Conduit shall be sized to suit the number, type, and size of conductors as specified in Division 16, Electrical, Specifications.

C. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

D. Control Valves:

1. Verify correctness of installation.
2. Verify proper control action.
3. Adjust limit switch settings.
4. Adjust opening and closing speeds, and travel stops.
5. Stroke control valves by means of associated controller.

E. Control Dampers:

1. Verify correctness of installation.
2. Verify proper control action.
3. Adjust limit switch settings.
4. Adjust opening and closing speeds, and travel stops.
5. Stroke control dampers by means of associated control output.

F. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

G. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (such as: terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing: Tests and certification shall be as specified in Section 01756, Testing and Facility Startup, and Section 01640, Manufacturers' Services and Training.

3.04 MANUFACTURER'S SERVICES

1. Provide manufacturer's services in conformance with requirements of Section 01640, Manufacturers' Services and Training.
2. Manufacturer's Representative:
   a. Present at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
      1) 4 person-days for installation, assistance, and inspection.
      2) 4 person-days for functional and performance testing and Manufacturer's Certificate of Proper Installation.
      3) 4 person-days for prestartup classroom or Site training.
      4) 4 person-days for facility startup.
      5) 4 person-days for post-startup training.

3.05 TRAINING

A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.

B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.

B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.

C. Adjustment Record:

1. Prepare complete record of system adjustments for each control system.
2. Indicate deviations from specified temperatures.
3. Include copy of completed record in each copy of Operation and Maintenance Manual.

3.07 CLEANING AND TOUCHUP PAINTING

A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

END OF SECTION

SECTION 15901
HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 15900, Instrumentation and Control Devices for HVAC.

B. The requirements of this section shall be provided in addition to those listed in Section 15900, Instrumentation and Control Devices for HVAC.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01612, Anchorage and Bracing.

1.03 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

C. HVAC Control Panel (HCP) Spare Lamps: Furnish spare lamps for each type and color of pilot light used, a minimum of one per HCP, stored inside HCP in dummy light sockets secured to back panel surface.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCP)

A. Provide at locations shown on the Drawings for convenient operator interface with control system.

B. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated.

C. HCP Contents: Set point adjustment dials, gauges, receiver controllers, manual timers, time clocks, microprocessor control modules, electronic indication relays, control switches, transformers, pilot lights, alarm lights, display screens, keypads, and other devices necessary for particular system.

D. HCP Construction:

1. Construct each HCP to NEMA 250 rating as indicated in Schedule below**,** except where indicated otherwise:

HVAC Control Panel (HCP) NEMA 250
Construction Schedule

Location	NEMA 250 Type
Penthouse	12

2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
3. Hinged front door with locking handle.
4. Flush-mount manual switches, pilot lights, and direct-reading gauges on front panel face.
5. Identify front panel mounted devices and HCP with labeling in accordance with Section 15900, Instrumentation and Control Devices for HVAC.

E. Panel Listing: Panels shall bear UL or ETL listing mark stating, “LISTED ENCLOSED INDUSTRIAL CONTROL PANEL.”

F. Control Devices:

1. Mount inside HCP.
2. Prewired internally.
3. Terminate wires leaving HCP at separately numbered terminal strips (one terminal pair per circuit).
4. Furnish individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
5. Refer to the Drawings for power and control circuit requirements.
6. Identify wires by color coding or numerical tags at both ends.
7. Wire control devices without splices to the terminal strip.
8. Furnish integral circuit protection for panel mounted control devices.

G. Terminal Blocks:

1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
3. Furnish permanent, legible identification, clearly visible with protective cover removed.
4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.
5. Size lugs for terminal block screws and for the number and size of wires terminated.
6. Provide screwdriver access for blade width of a minimum of 3/16 inch or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.

H. Schematic Diagrams:

1. Furnish black and white graphic of smooth or engraved laminated plastic.
2. Mount on front face of HCP showing equipment within respective systems.
3. Show pilot lights, pressure gauges, and temperature-indicating dials on schematic in locations that correspond to actual system location.
4. Locate manual selector switches directly below equipment symbol being controlled.

I. Miscellaneous Accessories:

1. Furnish panel as-built electrical wiring diagrams and schematics, secured to inside of panel door, or enclosed in plastic jackets placed inside each panel.
2. Install plastic or stick-on labels on interior control devices to identify them in conjunction with control schematics.

2.02 AUTOMATIC CONTROL VALVES (ACV)

A. General:

1. Fully proportioning with modulating plugs for equal percentage of linear flow characteristics.
2. Valve Body and Trim: Sufficient to handle system pressure and temperature.
3. Sized for a maximum pressure drop of 5 psi for chilled water valves and 3 psi for all other valves.

B. Valves 1/2 Inch Through 1-1/4 Inches:

1. Constructed with cast brass body and screwed ends, except sweat type ends for glycol systems.
2. Trim: Removable cage providing valve plug guiding throughout entire travel range.
3. Type 304 stainless steel stem.
4. Removable bonnet, cage, stem, and plug assembly.

C. Valve Actuators:

1. Sufficient power for intended duty.
2. Capable of closing against differential pressures to be encountered.
3. Constructed and piped to fail to full heating upon loss of control signal.
4. Capable of being sequenced either with other valves where required by sequence of operation.
    a. Where such sequencing is required, actual spring range, when adjusted for spring shift, shall allow no overlapping to occur.
    b. If spring shift causes overlap, furnish pilot positioning operator.
5. Cast aluminum body with spring return piston operated by synthetic rubber diaphragm.
6. Manufacturers:
    a. Johnson Controls.
    b. Siemens Building Technologies.
    c. Honeywell.
    d. Delta.

2.03 ELECTRIC THERMOSTATS (ET)

A. Process Area Room Thermostat (ET):

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 degrees F to 90 degrees F dial.
3. Concealed or external adjustments.
4. Adjustable sensitivity.
5. Insulating back where exterior wall mounting is indicated.
6. Locking wire protective guard.

2.04 ELECTRONIC SENSORS

A. Temperature (TS):

1. General Requirements:
    a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.

b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	± 0.5°F
Room Temperature	± 0.5°F
Duct Temperature	± 0.5°F
All Others	± 0.75°F

2. Room Temperature (TS-1):
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Shall have the following options when specified:
      1) Set point reset slide switch providing plus or minus 3 degrees F (adjustable) range.
      2) Individual heating/cooling set point slide switches.
      3) Momentary override request pushbutton for activation of after-hours operation.
      4) Analog thermometer.
3. Room Temperature Sensors with Integral Display (TS-2):
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Integral LCD display and four button keypad with the following capabilities:
      1) Display room and outside air temperatures.
      2) Display and adjust room comfort set point.
      3) Display and adjust fan operation status.
      4) Timed override request pushbutton with LED status for activation of after-hours operation.
      5) Display controller mode.
      6) Password selectable adjustment of set point and override modes.
4. Duct Temperature (TS-3):
   a. Accuracy: Plus or minus 1 degree F.
   b. Range:
      1) Heating: 40 degrees F to 140 degrees F.
      2) Cooling: 30 degrees F to 100 degrees F.

c. Element:
1) Rigid insertion, 12-inch length, through sealed opening in center of duct.
2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 20 feet long, serpentined across full area of airflow.

5. Outdoor Temperature (TS-4):
a. Accuracy: Plus, or minus 1 degree F.
b. Range: Minus 40 degrees F to 140 degrees F.
c. Cover: Weathertight, with sealed conduit connection and sun shield.

B. Differential Pressure (DP):

1. General:
a. Temperature compensated.
b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0V dc to 10V dc according to differential pressure between high- and low-pressure ports.
c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.
d. Capable of withstanding up to 150 percent of rated pressure without damage.
e. Compatible with 14V dc to 30V dc supply voltage range.

C. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
a. Application: Monitoring status of direct drive equipment.
b. Current-operated solid-state relay.
c. Split core design.
d. Trip Setpoint: Fixed.
e. Output: Digital switch.
f. Sensor Power: Induced from line.
g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. Adjustable Setpoint, Digital Output Current Switch:
a. Application: Monitoring status of belt drive equipment.
b. Current-operated solid-state relay.
c. Split core design.
d. Trip Setpoint: Adjustable.
e. Output: Digital switch, with status LED.

f. Sensor Power: Induced from line.
g. Manufacturer and Product: Veris; Hawkeye 708/908.

3. Adjustable Setpoint, Digital Output, AFD Current Switch:
   a. Application: Monitoring status of belt-drive or direct-drive equipment controlled by an AFD.
   b. Microprocessor-based current-operated solid-state relay.
   c. Automatic compensation for AFD frequency and current changes.
   d. Split core design.
   e. Trip Setpoint: Self-calibrating.
   f. Output: Digital switch, with normal and alarm status LED.
   g. Sensor Power: Induced from line.
   h. Manufacturer and Product: Veris; Hawkeye 904.

2.05 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0-volt to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0-volt to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 26, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Pilot Relays:

1. Plug-in type.
2. Interchangeable.
3. Mounted on a circuit board.
4. Wired to numbered terminal strips.

C. Motorized Step Controllers: Furnish with adjustable (from 1 degree F to 10 degrees F) deadband between heating and cooling functions.

D. Receiver Controllers:

1. Modulating temperature, pressure, or humidity type.
2. Adjustable gain with amplification ratio up to 40 to 1.
3. Dual input (submaster) instruments to have adjustable ratio or reset range.
4. Furnish dials for set point, gain and, where applicable, ratio or reset range.
5. Mount inside HCP.

6. Furnish test probe points to permit analysis of input signal(s) without interrupting controller.
7. Mount pressure gauge on instrument showing output air pressure supplied to controlled device.
8. Include proportional integral control.
    a. Designed to minimize internal hysteresis.
    b. Either integral or remote set point adjustment.
    c. Integral time constant adjustment.
    d. Function as integral feedback device with output that varies progressively, depending on degree of offset and time since transient was detected.
9. Capable of being remotely reset from existing building automation system.

E. Manual Timer (MT):

1. 12-hour, SPST, 120-volt, 20-amp.
2. Spring wound.
3. HOLD feature to override the time clock during off-hour operation.
4. Install on front cover of HCP.
5. Manufacturers:
    a. Marktime.
    b. Dayton.
    c. Nutone.

F. Time Clock (TC):

1. Electronic 7-day programmable type.
2. 8-hour battery backup feature.
3. Mount inside HCP.
4. Manufacturers:
    a. Paragon.
    b. Omron.

G. Electronic Indication:

1. Furnish temperature-indicating dials or digital read-outs on HCP.
2. 2-1/2-inch minimum rectangular.
3. Temperature sensing dc bridge circuit.

PART 3 EXECUTION

3.01 INSTALLATION

A. Control Dampers:

1. Install at locations indicated on the Drawings and in accordance with manufacturer's instructions.
2. Install square and free from racking with blades running horizontally.
3. Operate opposed blade dampers from a power blade or drive axle.
4. Bracing:
   a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
   b. Install at every horizontal and vertical mullion.

END OF SECTION

SECTION 15902
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 15900, Instrumentation and Control Devices for HVAC.

B. The requirements of this section shall be provided in addition to those listed in Section 15900, Instrumentation and Control Devices for HVAC.

1.02 DEFINITIONS

A. ASCII: ANSI X3.4, Information Systems—Coded Character Sets—7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).

B. BACnet: ASHRAE 135, BACnet, Data Communication Protocol for Building Automation and Control Networks.

C. Distributed Control: System whereby control processing is decentralized and independent of central computer. Control system is built up of standalone controllers. Single controller failure shall not impact more than one system.

D. Ethernet: ISO/IEC 8802-3. The most common high performance peer-to-peer LAN protocol.

E. Human-Machine Interface (HMI): Method by which operator communicates with HVAC Control System. Allows operator to command, monitor, and program control system.

F. Input/Output (I/O): Connections between computer and sensors and actuators.

G. Integration:

1. Ability of control system components from different manufacturers to connect and provide coordinated control via real-time data exchange through common communications data exchange protocol.
2. Integration shall extend to operator’s workstation software, which shall support user interaction with control system components.
3. Methods of integration include industry standard protocols, such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC), or integrator interfaces between manufacturer’s systems.

H. Interoperability: Ability of equipment to communicate mutually.

I. Internet Protocol (IP): Network layer protocol originally created by Defense Advanced Research Project Agency to facilitate data communication between U.S. Defense Department and defense contractors, including universities and manufacturers.

J. Local Area Network (LAN): Network in which devices can communicate directly without going through intervening routers. LANs commonly used by DDC system Suppliers include Ethernet (ISO 8802-3), ARCNET, Echelon LonTalk, and EIA 485.

K. Master-Slave/Token-Passing (MS/TP): One of the data link layers created specifically for use with BACnet messages.

L. Network:

1. System of distributed control units that are linked together on communication highway.
2. Allows sharing of point information between control units.
3. Provides central monitoring and control of entire system from any distributed control unit location.
4. Primary networks provide peer-to-peer communications.
5. Secondary networks provide either peer-to-peer, master-slave, or supervised token-passing communications.

M. Peripheral: Input/Output equipment used to communicate with computer and make copies of system outputs. Peripherals include CRT, printer, tape deck, diskette.

N. PID (Proportional, Integral, Derivative) Control Loop: Mathematical calculation used to evaluate control input and determine control output value required to maintain input value at set point. Shall have operator adjustable maximum rate of change, P and D gains, and loop response time delay. Loop shall be self-integrating so no integral constant is required and not be subject to integral windup.

O. Transmission Control Protocol (TCP): Connection-oriented protocol used to convey multiple related messages (such as: file transfers, Web pages, etc.).

P. Abbreviations that may be used in this section:

1. BIOS: Basic Input Output System.
2. DDC: Direct Digital Control.
3. IBM: International Business Machines, Inc.

4. LCD: Liquid Crystal Display.
5. PC: Personal Computer.
6. PID: Process Instrumentation Diagram.
7. PI: Pressure Indicator.

1.03 QUALITY ASSURANCE

A. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years.
2. Future compatibility shall be supported for no less than 10 years.
3. Compatibility shall be defined as:
   a. Ability to upgrade existing microelectronic controllers to current level of technology, and extend new microelectronic controllers on previously installed network.
   b. Ability for any existing microelectronic controller microprocessor to be connected and directly communicate with new microelectronic controllers without bridges, routers, or protocol converters.

1.04 SYSTEM PERFORMANCE

A. System shall conform to the following performance standards:

1. Graphic Display:
   a. Minimum of 20 dynamic points.
   b. Current data displayed within 20 seconds of request.
2. Graphic Refresh: System shall update dynamic points with current data within 30 seconds.
3. Object Command:
   a. Maximum time between command of binary object by operator and reaction by device shall be 10 seconds.
   b. Analog objects shall start to adjust within 10 seconds.
4. Object Scan: Changes of state and change of analog values shall be transmitted over high-speed network such that any data used or displayed at controller or workstation will be current, within prior 60 seconds.
5. Alarm Response Time: Maximum time from when object goes into alarm to when it is annunciated at workstation shall not exceed 45 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.

7. Performance: Programmable Controllers shall be able to execute DDC PID control loops at selectable frequency from at least once every 5 seconds. Controller shall scan and update process value and output generated by this calculation at this same frequency.
8. Multiple Alarm Annunciation: Workstations on network shall receive alarms within 5 seconds of each other.
9. Reporting Accuracy: Table 1 lists minimum acceptable reporting accuracies for values reported by specified system.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space temperature	±0.5°C or ±1°F
Ducted air	±1.0°C or ±2°F
Outside air	±1.0°C or ±2°F
Relative humidity	±5% RH
Air flow (terminal)	±10% of reading[1]
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa or ±0.1" WC
Electrical Power	5% of reading[2]
Carbon Monoxide (CO)	± 50 ppm
Carbon Dioxide (CO_2)	± 50 ppm

[1](10% – 100% of scale) (cannot read accurately below 10%).
[2]Not including utility supplied meters.

1.05 EXTRA MATERIALS

A. Spare Parts and Special Tools: Submit a list of manufacturers recommended spare parts including part numbers, current price list, and contact for purchasing.

B. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

PART 2 PRODUCTS

2.01 STANDALONE DDC CONTROL SYSTEM

A. Standalone Custom Controllers (DDC-1):

1. General:
   a. Provide adequate number of controllers to provide performance specified in Article System Performance and as indicated on the Drawings.
   b. Microprocessor based true no-host system; no PC or “host” computer required to perform control functions or communications, capable of standalone operation, providing control functions without being connected to a network.
2. Performance:
   a. Set points, controller operating system, and programming shall be resident in EEPROM, within controller.
   b. Capable of executing DDC loops and custom control routines.
   c. DDC loop control programming with editable proportional, integral, and derivative control parameters.
   d. DDC loops shall have editable high and low output limits as well as editable failure output values.
   e. Software control reaction time shall be programmable to be no slower than 5 seconds.
   f. DDC loops shall be programmable to operate at user defined intervals with maximum frequency of 1 second.
   g. Sufficient memory to support its operating system, database, and programming requirements.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
   a. Controller shall be mounted in locking enclosure. Refer to Section 15901, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP), for enclosure details.
   b. Controller used outdoors or in wet ambient conditions shall be mounted within waterproof enclosure and rated for operation at

minus 40 degrees C to 65 degrees C (minus 40 degrees F to 150 degrees F).

c. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degree C to 50 degrees C (32 degrees F to 120 degrees F).

4. Clock:
   a. Real time clock that shall remain active during power failure for up to 7 days under normal operating conditions.
   b. When controller is used with higher level system, time clock shall be automatically synchronized with system controller.
5. Software:
   a. Software for controller setup, programming, and editing of database.
   b. In English language.
   c. IBM PC compatible.
   d. PI and PID control loops.
   e. Programming subroutine blocks available to be used in any combination for program modifications.
   f. As a minimum, routines shall include:
      1) Time- or event-based scheduling.
      2) Offline, fill-in-the-blank programming of controller.
      3) Operating and programming error messages and diagnostics.
      4) Database save and restore.
      5) Adaptive optimum start/stop.
      6) Run time totalization.
      7) Alarm detection and dial out.
      8) Historical Trending: Trend data shall be fully compatible with Microsoft Access and Excel.
   g. Documentation:
      1) Provide to Owner, before completion of Project:
         a) Electronic copy of programming tool software.
         b) Electronic copy of control logic program used in controller.
         c) User’s manual for software operation.
         d) Include appropriate cable for interconnection between PC serial port and controller.
6. Diagnostics:
   a. Controller shall contain the following diagnostic information:
      1) LEDs indicating status of main board, communications Transmit and Receive, and Binary Output on/off.
      2) Information regarding failure of analog or change of state of any binary point. Controller must then capture an image of all points at value or state at time of event/alarm. This data must be able to be viewed from a set of screens that are

labeled with alarm point, date and time of occurrence, and cause of failure.

3) Self test procedure for checking communications and verifying functionality of memory and database.
4) Upon detection of communication loss, retransmission shall be attempted.
5) Continuing failure shall cause trouble signal to be annunciated at HCP.

7. External Communication:
   a. Allow service tool editing of programming while controller is in total standalone operation.
   b. Provide port for connection to LAN.
8. Electrical:
   a. Power:
      1) ON/OFF switch inside cabinet.
      2) Controller Power: 24V, 50/60 Hz.
      3) On-board isolation transformer or dedicated transformer, rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.
      4) Battery Backup: Local controller must provide backup of all memory for period of 7 days under normal operating conditions if commercial power to controller is interrupted.
   b. Connections:
      1) Plug-in terminal blocks, in accordance with requirements of Section 15901, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP).
      2) Logic card containing active electrical components shall be easily removable from wiring base without use of tools.
      3) Provide quick disconnect interconnection with electrical wiring.
   c. Immunity to Power and Noise:
      1) Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
      2) Operation shall be protected against electrical noise of 5 Hz to 120 Hz and from keyed radios up to 5W at 1 meter (3 feet).
      3) Provide filters, as required to comply with applicable FCC regulations.
   d. Power Loss/Restart:
      1) Tolerant of power failures.
      2) Memory shall be nonvolatile or unit shall hold memory up to 30 days minimum on backup batteries.

3) When power failure has occurred and power is restored, controller shall restart automatically and without operator intervention.
4) Restart Procedures:
   a) Come online.
   b) Update monitored functions.
   c) Implement special facility startup strategies as required.
5) Resume operation based on current time and status.

9. Input/Output:
   a. Controller shall be configurable using modular Input/Output points to allow for system customization and expansion.
   b. Each controller shall monitor analog inputs and analog outputs, and perform minimum 10 bit A-to-D and 8 bit D-to-A conversion.
   c. Local controller shall receive signals from industry standard sensors and input devices and directly control actuators and control devices.
   d. Controller shall have capability to monitor and control the following types of inputs and outputs:
      1) Analog Inputs:
         a) Current: 4 mA to 20 mA.
         b) Voltage: 0V dc to 10V dc.
         c) Thermistor.
         d) 1,000 ohm RTD.
      2) Binary Inputs:
         a) Isolated dry contact closure.
         b) Pulse.
      3) Analog Outputs:
         a) Current: 4 mA to 20 mA.
         b) Voltage: 0V dc to 10V dc.
      4) Binary Outputs: 24V ac, Triac switch.
   e. Output points must be available with manual software and hardware overrides with feedback indication that an output is presently overridden.
   f. Port Isolation:
      1) Individually, electrically isolated to protect against transients, spikes, and power surges.
      2) Optically isolated from each other, controller circuit board, and from power wiring.
      3) Optical isolation either as integral component to controller or as a separate interface device between controller and field wiring.
   g. Quantity of I/O Points: As required to provide equipment function as described in sequences of operation.

10. Expansion Capability:
    a. Capable of accepting expansion modules for addition of:
        1) Memory.
        2) Input/Output points.
11. Trending:
    a. Minimum of eight user selectable points shall be able to be logged, with a minimum of 24 samples per log.
    b. Start and stop times for each trend log shall be definable or continuous.
12. User Interface:
    a. Local keypad and display shall be provided for each controller for interrogating and editing data.
    b. Keypad and display shall be built-in to controller, with minimum one line by 20 character LCD display.

B. Remote Communications:

1. Provide modem to allow dial-in for complete EIA/TIA 232F access for system monitoring, control, and programming.
2. Possible to retrieve and save system panel's database and to download that database from remote location over standard telephone lines.
3. Enable auto-dial out of alarms including equipment failures and temperatures out-of-range for automatic annunciation and logging at remote location.

2.02 NETWORK COMMUNICATION

A. Control products for Networked DDC Control System shall comprise a BACnet network. PC Workstations and Building Controller components shall meet ASHRAE 135, BACnet.

B. Operator Workstations and Building Controllers shall be installed on a primary high-speed peer-to-peer ISO 8802-3 Ethernet network.

C. Custom Application Controllers and Application Specific Controllers may be installed on either primary high-speed peer-to-peer ISO 8802-3 Ethernet network, or Secondary network.

D. Provide all communication media, connectors, repeaters, hubs, and routers necessary for network.

E. Building Controllers shall have communications port for connections with operator interfaces using BACnet Data Link/Physical layer protocol.

F. Provide device on network with minimum 28,000 baud modem that will allow remote operator interface using BACnet Data Link/Physical layer protocol. Modem shall allow for communication with controllers on this network as described below.

G. Communications services over network shall result in operator interface and value passing that is transparent to network architecture as follows:

1. Connection of operator interface device to any one controller on network shall allow operator to interface with other controllers as if that interface were directly connected to other controllers.
2. Data, status information, reports, system software, custom programs for controllers shall be available for viewing and editing from any controller on network.
3. Database values (such as: points, software variable, custom program variables) of any one controller shall be readable by any other controller on network.
4. This value passing shall be automatically performed by controller when reference to point name not located in that controller is entered into controller's database.
5. Operator/installer shall not be required to set up any communications services to perform network value passing.

H. Time clocks in controllers shall be automatically synchronized daily.

2.03 NETWORK HUMAN-MACHINE INTERFACE

A. Operator Interface:

1. Furnish PC based operator workstation.
2. Workstation shall be able to access all information in system.
3. Workstation shall reside on same high-speed network as building controllers, and shall also be able to dial into system.

B. Communications:

1. Workstation information access shall use BACnet Protocol.
2. Communication shall use ISO 8802-3 (Ethernet) Physical/Data Link layer protocol.
3. Remote communications shall use BACnet Point to Point Physical/Data Link Layer Protocol.

C. Hardware:

1. Each operator workstation shall consist of the following:
   a. Personal Computer:
      1) Furnish one IBM compatible PC.
      2) Features:
         a) Monitor: 17-inch, minimum, SVGA.
         b) CPU: Intel Pentium 4, minimum, and operate at a minimum of 1.6 GHz.
         c) RAM: 256 Megabytes, minimum.
         d) Diskette Drive: One with 1.44 Megabytes capacity.
         e) Optical Drive: 40X speed, CD-ROM.
         f) Hard Drive: 10 GB capacity, minimum, with minimum access time of 12 milliseconds.
         g) Mouse: Two button.
      3) Furnish required serial, parallel, and network communication ports, and cables for proper system operation.
   b. Modem:
      1) Auto-dial telephone modem and associated cables as required for communication to remote buildings, and workstations.
      2) Transmit at minimum of 56,000 baud, and communicate over voice-grade telephone lines.
   c. Printer:
      1) Each workstation shall have one printer, with tractor feed, and associated cables.
      2) Capable of minimum 160 characters per second operation and compatible with standard parallel or serial communications.
      3) Supply one box of minimum 2,000 sheets of printer paper and two printer ribbons or cartridges.
   d. BACnet:
      1) Workstation shall use Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135, to communicate with BACnet objects in network.
      2) Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.

D. System Software:

1. Operating System:
   a. Commercially available, concurrent multitasking.
   b. Support use of other common software applications that operate under DOS or Microsoft Windows.
   c. Acceptable operating systems are Windows 2000 or Windows XP.
2. System Graphics:
   a. Operator workstation software shall be graphically oriented.
   b. System shall allow display of up to 10-graphic screens at once for comparison and monitoring of system status.
   c. Provide method for operator to easily move between graphic displays and change size and location of graphic displays on screen.
   d. Able to be modified while on line.
   e. Operator with proper password level shall be able to add, delete, or change dynamic points on graphic.
   f. Dynamic points shall include analog and binary values, dynamic text, static text, video, and animation files.
   g. Ability to show animation of equipment.
3. Custom Graphics:
   a. Created with use of commonly available graphics packages, such as PC Paint.
   b. Graphics generation package shall create and modify graphics that are saved in industry standard formats such as PCX, BMP, GIF, and JPEG.
   c. Graphics generation package shall also provide capability of capturing or converting graphics from other programs such as Designer, or AutoCAD.
4. Graphics Library:
   a. Complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators.
   b. Include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork.
   c. File format compatible with graphics generation package program.
5. Engineering Units:
   a. Allow for selection of desired engineering units (such as: inch pound or SI) in system.
   b. Unit selection shall be able to be customized by locality to select desired units for each measurement.
   c. Engineering units on this Project shall be Standard Inch Pound.

E. System Applications:

1. Each workstation shall provide operator interface and offline storage of system information. Provide the following applications at each workstation:
   a. Automatic System Database Save and Restore:
      1) Store on hard disk copy of current database of each building controller.
      2) Database shall be updated whenever change is made in any panel in system.
      3) Storage of data shall be automatic and not require operator intervention.
      4) In the event of database loss in building management panel, first workstation to detect loss shall automatically restore database for that panel.
   b. Manual Database Save and Restore:
      1) System operator with proper password clearance shall be able to archive database from any system panel and store on magnetic media.
      2) Operator shall also be able to clear panel database and manually initiate download of specified database to any panel in system.
   c. System Configuration:
      1) Workstation software shall provide graphical method of configuring system.
      2) User with proper security shall be able to add new devices and assign modems to devices.
      3) This shall allow for future system changes or additions.
   d. Online Help:
      1) Context sensitive to assist operator in operation and editing of system.
      2) Available for all applications and shall provide relevant data for that particular screen.
      3) Additional help information shall be available through use of hypertext.
   e. Security:
      1) Each operator shall be required to log on to system with user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator.
      2) System supervisor shall have ability to set passwords and security levels for other operators.
      3) Each operator password shall be able to restrict operators' access for viewing and/or changing each system application, full screen editor, and object.

4) Each operator shall automatically be logged off system if no keyboard or mouse activity is detected.
5) Auto logoff time shall be set per operator password.
6) System security data shall be stored in encrypted format.

f. System Diagnostics:
1) System shall automatically monitor operation of workstations, printers, modems, network connections, building management panels, and controllers.
2) Failure of any device shall be annunciated to operator.

g. Alarm Processing:
1) Any object in system shall be configurable to alarm in and out of normal state.
2) Operator shall be able to configure alarm limits, warning limits, states, and reactions for each object in system.
3) Alarm Reactions:
a) Operator shall be able to determine what actions, if any, are to be taken, by object (or point), during alarm.
b) Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics.
c) Each of these actions shall be configurable by workstation and time of day.
d) Object in alarm that has not been acknowledged within operator specified time period shall be rerouted to alternate operator specified alarm receipt device.
4) Binary Alarms:
a) Each binary object shall be set to alarm based on operator specified state.
b) Capability to disable alarming when associated equipment is turned off or is being serviced.
5) Analog Alarms:
a) Each analog object shall have both high and low alarm limits and warning limits.
b) Alarming must be able to be automatically and manually disabled.

h. Trend Logs:
1) Operator shall be able to define custom trend log for any data in system.
2) This definition shall include interval, start-time, and stop-time. Trend intervals of 1 minute, 5 minutes, 15 minutes, 30 minutes, and 60 minutes as well as once a shift (8 hours),

once a day, once a week, and once a month shall be selectable.

3) Trends shall start based on the hour. Each trend shall accommodate up to 64 system objects.
4) System operator with proper password shall be able to determine how many samples are stored in each trend.
5) Trend Data:
   a) Sampled and stored on building controller panel, and archived on hard disk.
   b) Able to be viewed and printed from operator interface software.
   c) Storable in tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.

i. Alarm and Event Log:
   1) Operator shall be able to view logged system alarms and events from any location in system.
   2) Events shall be listed chronologically.
   3) Operator with proper security level may acknowledge and clear alarms.
   4) All that have not been cleared by operator shall be archived to hard disk on workstation.

j. Object and Property Status and Control:
   1) Provide method for operator with proper password protection to view, and edit if applicable, status of any object and property in system.
   2) Statuses shall be available by menu, on graphics, or through custom programs.

k. Clock Synchronization:
   1) Real time clocks in building control panels and workstations shall be synchronized on command of operator.
   2) System shall also be able to automatically synchronize system clocks daily from any operator-designated device in system.
   3) System shall automatically adjust for daylight savings and standard time, if applicable.

l. Reports and Logs:
   1) Reporting package shall allow operator to select, modify, or create reports.
   2) Each report shall be definable as to data content, format, interval, and date.
   3) Report data shall be archived on hard disk for historical reporting.

4) Ability for operator to obtain real time logs of designated lists of objects.
5) Reports and logs shall be stored on PC hard disk in format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6) Reports and logs shall be readily printed to system printer.
7) Operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.
8) Custom Reports:
    a) Capable for operator to easily define any system data into daily, weekly, monthly, or annual report.
    b) Time and date stamped, and shall contain report title and name of facility.
9) Standard Reports: The following standard system reports shall be provided for this Project. Reports shall be readily customized to Project by Owner.
    a) Electrical Meter Report:
        (1) Monthly report showing daily electrical consumption and peak electrical demand for each building meter.
        (2) Annual (12 months) summary report showing monthly electrical consumption and peak demand for each meter.
    b) Gas Meter Report:
        (1) Monthly report showing daily natural gas consumption for each meter.
        (2) Annual (12 months) report showing monthly consumption for each meter.
    c) Weather Data Report:
        (1) Monthly report showing daily minimum, maximum, and average outdoor air temperature, and number of heating and cooling degree-days for each day.
        (2) Annual (12 months) report showing minimum, maximum, and average outdoor air temperature for month, and number of heating and cooling degree days for each month.
    d) Tenant Override Reports:
        (1) Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC and lighting services.
        (2) Annual (12 months) report that shows override usage on monthly basis.

e) ASHRAE Guideline 3 Report:
(1) Daily report that shows operating condition of each chiller as required by ASHRAE Guideline 3. At minimum this report shall include:
(a) Chilled Water (or other fluid) inlet and outlet temperature.
(b) Chilled Water (or other fluid) flow.
(c) Chilled Water (or other fluid) inlet and outlet pressures.
(d) Evaporator refrigerant pressure and temperature.
(e) Condenser refrigerant pressure and liquid temperature.
(f) Condenser water inlet and outlet temperatures.
(g) Condenser water flow.
(h) Refrigerant levels.
(i) Oil pressure and temperature.
(j) Oil level (if applicable).
(k) Compressor refrigerant discharge temperature.
(l) Compressor refrigerant suction temperature.
(m) Manual entry field for addition of refrigerant.
(n) Manual entry field for addition of oil.
(o) Manual entry field for vibration levels.
(p) Motor amperes per phase.
(q) Motor volts per phase.
(r) PPM refrigerant monitor levels.
(s) Purge exhaust time or discharge count.
(t) Ambient temperatures (dry bulb and wet bulb).
(u) Date and time data logged.

F. Workstation Applications Editor:

1. General:
a. Each PC workstation shall support full screen editing of system applications.
b. Editor for each application at PC workstation.
c. Applications shall be downloaded and executed at appropriate controller panels.

d. Full screen editor for each type controller and application that shall allow operator with proper password to view and change configuration, name, control parameters, and system set points.

2. Scheduling:
   a. Editor for scheduling application shall be provided at each workstation.
   b. Monthly calendar for each schedule.
   c. Exception schedules and holidays shall be shown clearly on calendar.
   d. Capable of allowing several related objects to follow a schedule.
   e. Advance and delay time for each object shall be adjustable from this master schedule.
   f. Operator with proper password level shall be able to modify schedule.
   g. Schedules shall be able to be easily copied between objects and/or dates.
3. Equipment Coordination:
   a. Full screen editor shall allow equipment to be grouped for proper operation as specified in sequence of operations.
   b. Include coordination of VAV boxes with their associated Air Handling Equipment.
4. Chiller System:
   a. Chiller plant control application shall be configured using full screen editor and shall provide operating status for system. Display shall include:
      1) System mode of chiller plant.
      2) Chiller enable/disable status.
      3) System supply water set point.
      4) System supply and return water temperature.
      5) System chilled water pump status.
      6) System chilled water flow.
      7) Bypass pipe flow rate (if applicable).
      8) Current chiller plant control operation.
      9) Add information.
      10) Subtract information.
      11) System failure information.
      12) Chiller failure information.
      13) Rotation information.
      14) Override capabilities to force an add control, subtract control, or change of sequence.
      15) Remove chiller from sequence temporarily for service purposes.

5. Custom Application Programming:
   a. Provide tools to create, modify, and debug custom application programming.
   b. Operator shall be able to create, edit, and download custom programs at same time that other system applications are operating.
   c. System shall be fully operable while custom routines are edited, compiled, and downloaded.
   d. Programming language shall have the following features:
      1) English language oriented and based on syntax of programming languages such as BASIC. It shall allow for free form or fill in the blank programming. Alternatively, programming language can be graphically based using function blocks if blocks are available that directly provide functions listed below, and that custom or compound function blocks can be created.
      2) Full screen character editor/programming environment. Editor shall be cursor/mouse driven and allow user to insert, add, modify, and delete code from custom programming. It shall also incorporate word processing features such as cut/paste and find/replace.
      3) Allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.
      4) Editor/programming environment shall have debugging/simulation capability that allows user to step through program and to observe intermediate values and results. Debugger shall also provide error messages for syntax and execution errors.
      5) Support conditional statements (if/then/else/else-if) using compound Boolean (and, or, and not) and/or relations (equal, less than, greater than, not equal) comparisons.
      6) Support floating point arithmetic using the following operators: +, -, /, x, square root, and xy.
      7) The following mathematical functions shall also be provided: Natural log, log, absolute value, and minimum/maximum value from a list of values.
      8) Predefined variables that represent clock time, day of week, and date. Variables that provide interval timing shall also be available. Language shall allow for computations using these values.
      9) Ability to predefined variables representing status and results of System Software, and shall be able to enable, disable, and change values of BACnet objects in system.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to Section 15900, Instrumentation and Control Devices for HVAC, for requirements.

END OF SECTION

SECTION 15905
HVAC INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
3. ASTM International (ASTM):
    a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    b. C547, Standard Specification for Mineral Fiber Pipe Insulation.
    c. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    d. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
    e. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    g. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
    h. G22, Standard Practice for Determining Resistance of Plastics to Bacteria.
4. National Fire Protection Association (NFPA):
    a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
    b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
    c. 259, Standard Test Method for Potential Heat of Building Materials.
5. UL.

1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled air or return ducts in such systems.

B. Warm Air Ductwork: Designed to convey mechanically heated air or return ducts in such systems.

1.03 SUBMITTALS

A. Action Submittals: Product description, list of materials and thickness for each service or equipment scheduled, locations, and manufacturer's installation instructions.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Operation and maintenance data as specified in Section 01782, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Materials furnished under this specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Project Site for use must have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Marked "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation: Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, Adhesives, Vapor Barrier Materials and Other Accessories, Except as Specified Herein: Noncombustible.
2. Do not use fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration resulting from the effects of moisture or high humidity are not acceptable.
4. Provide materials including facings, mastics, and adhesives, with fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with ASTM E84 (NFPA 255) methods.

E. Materials exempt from fire-resistant rating:

1. Nylon anchors.
2. Treated wood inserts.

F. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:

1. Polyurethane insulation.
2. PVC casing.
3. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1 Minus 20 Degrees F to 500 Degrees F):

1. Fiberglass, UL-rated, preformed, sectional rigid, minimum 4 pounds per cubic foot (pcf) density, K factor 0.23 maximum at 75 degrees F mean, with factory-applied all-service jacket (ASJ).

2. All-Service Jacket:
   a. Composed of reinforced kraft paper and aluminum foil laminate.
   b. Provide self-sealing lap to facilitate closing longitudinal and end joints.
3. Manufacturers and Products:
   a. CertainTeed; Preformed Pipe Insulation.
   b. Johns Manville; Micro-Lok HP.
   c. Owens/Corning; Fiberglas Pipe Insulation.
   d. Knauf; Crown Pipe Insulation.

B. Type P1A—Fiberglass, ASTM C547, Type 2, 650 Degrees F, Maximum; Class 3, 850 Degrees F, Maximum:

1. Fiberglass, minimum 5 pcf density, K factor 0.34 maximum at 300 degrees F mean, with factory-applied all-weather jacket (AWJ) for temperatures ambient to 850 degrees F.
2. Manufacturers and Products:
   a. CertainTeed; Preformed Pipe Insulation.
   b. Johns Manville; Micro Lok.
   c. Knauf; Rocksil Mattress.
   d. Owens/Corning; Fiberglas Pipe Insulation.

C. Type P2—Calcium Silicate (ASTM C533, 1,200 Degrees F, Maximum):

1. Calcium silicate, minimum 12 pcf density, K factor 0.46 maximum at 300 degrees F mean, without factory-applied jacket.
2. Manufacturers and Products:
   a. Owens/Corning Fiberglass; Kaylo 10.
   b. Johns Manville; Thermo-12 Gold.
   c. Calsilite; 1,200-degree thermal insulation.

D. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water vapor transmission 0.1 perm-inch, or less.
4. Manufacturers and Products:
   a. Armacell; AP Armaflex.
   b. Nomaco; K-Flex LS.

E. Type P4—Cellular Glass:

1. Cellular glass, closed cell, rigid, nominal 8 pcf density, maximum K factor 0.33 at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 900 degrees F.
2. Manufacturer and Product: Pittsburgh-Corning; Foamglas.

2.03 DUCT INSULATION

A. Type D1—Blanket (ASTM C553, Type 1, Class B3):

1. Fiberglass, nominal 1 pcf density blanket, K factor 0.31 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 250 degrees F.
2. Manufacturers and Products:
   a. CertainTeed; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Owens/Corning Fiberglass; Soft R.
   d. Knauf; Ductwrap.

B. Type D2—Board:

1. Fiberglass, minimum 2.75 pcf density board, K factor 0.23 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures from 0 degree F to 450 degrees F.
2. Manufacturers and Products:
   a. CertainTeed; CertaPro Commercial Board.
   b. Knauf; Duct Slab.
   c. Owens/Corning Fiberglass; TIW.
   d. Johns Manville; 1000 Series Spin-Glass.

C. Type D3—Liner (ASTM C1071, Type 1):

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean, black composite coated surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
2. Liquid water repellency rating not less than 4 when tested in accordance with INDA IST 80.6.
3. Potential heat value not exceeding 3,500 Btu/lb when tested in accordance with NFPA 259 and meeting the classification of “Limited Combustible” as defined by NFPA 90A.
4. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
5. Resistant to microbial growth using a “no growth criteria” when tested in accordance with ASTM C1139, ASTM G21, and ASTM G22.
6. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. Johns Manville; Linacoustic (rectangular), Spinacoustic (Round).
   c. Knauf; Acoustic Duct Liner.

D. Type D4—Ceramic Fiber (to 2,300 degrees F):

1. UL-listed, 2-hour fire-rated, 6 pcf density, inorganic foil encapsulated ceramic fiber blanket.
2. Manufacturer and Product: Thermal Ceramics; Firemaster.

E. Type D5—Flexible Elastomeric (ASTM 534, Type I for tubular materials and Type II for sheet materials):

1. Closed-cell, sponge- or expanded-rubber materials.
2. Manufacturers and Products:
   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 150 degrees F.
2. Manufacturers and Products:
   a. Johns Manville; Zeston.
   b. Ceel-Co; 550.

B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product:
   a. RPR Products; INSUL-MATE.
   b. ITW, Pabco-Childers.

D. Type F4—Ceramic:

1. Insulating duct coating, fluid-applied coating with ceramic insulating particles.
2. Manufacturer and Product: ASTEC, by Insulating Coatings Corp., Inverness, FL.

PART 3 EXECUTION

3.01 APPLICATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

L. Insulate valve bodies, flanges, and pipe couplings.

M. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

N. Do not insulate flexible pipe couplings and expansion joints.

O. Do not allow insulation to cover nameplates or code inspection stamps.

P. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

Q. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

R. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

S. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

T. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

U. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF DUCTWORK INSULATION

A. General: Install insulation products in accordance with the manufacturer’s written instructions and in accordance with recognized industry practices.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulation. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation and protect it to prevent puncture and other damage. Tape all punctures.

E. Seal longitudinal and circumferential joints with FSK tape, and finish with fiberglass mesh fabric embedded in vapor barrier mastic.

F. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

G. Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

H. Refer to Section 15810, Metal Ducts and Accessories, for installation of internal duct liner.

3.03 INSTALLATION OF EQUIPMENT INSULATION

A. Application Requirements: Insulate where external surface temperature of equipment is below ambient temperature in the space, including surfaces that have a recognized possibility for condensation.

B. Install equipment thermal insulation products in accordance with manufacturer’s written instructions and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

C. Install insulation materials with smooth and even surfaces and on clear and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

D. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

E. Provide removable insulation sections to cover parts of equipment that must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames, and accessories.

F. Replace damaged insulation that cannot be repaired satisfactorily, including units with vapor barrier damage and moisture-saturated units.

G. Avoid using scrap pieces of insulation where larger sheets will fit.

3.04 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal all exterior joints to make watertight.

3.05 PIPING INSULATION REQUIREMENTS

A. Pipe Systems: See the Pipe Schedule on the Drawings. For pipe insulation thickness, refer to the Service and Insulation Thickness Schedule in Section 15080, Process Piping Insulation.

B. Refrigeration Suction:

1. Type P3, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 1 inch.
3. 3/4-inch thickness for pipe sizes over 1 inch.

C. Refrigeration Hot Gas Reheat:

1. Type P3, elastomeric.
2. 3/4-inch thickness.

D. Stack:

1. Type P1A.
2. 2-inch thickness for temperatures up to 700 degrees F.
3. 3-inch thickness for temperatures over 700 degrees F.

E. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.

2. Type P3, Elastomeric: Rigid insulation section with 9-inch long, 16-gauge galvanized steel saddle.

3.06 DUCTWORK INSULATION REQUIREMENTS

A. Mechanically Cooled and Heated Supply and Return Air, and Outside Air (Exposed to View):

1. Type D5.
2. 1-1/2-inch thickness.

B. Mechanically Cooled and Heated Supply and Return Air; (Within 30 Feet of Air Handling Unit):

1. Type D3, liner.
2. 1-1/2-inch thickness.

C. Outside Air Intake:

1. Type D1, blanket.
2. 1-1/2-inch thickness.

D. Sheet Metal Plenums:

1. Type D3, liner.
2. 1-1/2-inch thickness.

E. Air Distribution Devices: Refer to Section 15850, Air Outlets and Inlets, for requirements.

3.07 INSULATION FINISH REQUIREMENTS

A. Piping Insulation (Exposed to View, Indoors):

1. Type F1, PVC.
2. Type F3, aluminum.

B. Ductwork Insulation (Exposed to View, Indoors): Factory finish.

C. Piping Insulation (Outdoors):

1. Type F2, paint (for use with Type P3, elastomeric).
2. Type F3, aluminum.

D. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.08 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

SECTION 15950
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
   b. Procedural Standards for Measuring Sound and Vibration.
5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting, and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.

3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.
5. Employer of engineers and technicians regularly engaged in testing, adjusting, and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the Work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.

B. Adjust and balance the following systems:

1. Supply, return and exhaust air systems.
2. Heating and cooling systems.
3. Facility 715: FOG Building
    a. Existing hydronic heating systems.
    b. Non-potable hot water recirculation systems.
4. Facility 725: Digester Complex 2.
    a. New hydronic heating systems.

C. Multiple visits are expected to test, adjust, and balance the hydronic heating water system to minimize downtime as stages of construction are completed.

3.02 ADJUSTING BALANCING AIR SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
    a. Review Shop Drawings and installed system for adequate and accessible balancing devices and test points.
    b. Recommend to Engineer dampers that need to be added or replaced to obtain proper air control.

c. Verify proper startup procedures have been completed on the system.
d. Verify controls installation is complete, and system is in stable operation under automatic control.
e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer's recommended calibration interval before beginning the Work.

B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.

C. Equipment Data:

1. Collect the following data and included in final report:
   a. Type of unit.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
   d. Motor data (frame, hp, volts, FLA rpm, and service factor).
   e. Sheave manufacturer, size, and bore.
   f. Sheave centerline distance and adjustment limits.
   g. Starter and motor overload protection data.
   h. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
   b. After final adjustments, do not operate motor above nameplate amperage on any phase.
   c. After final adjustments, do not operate fan above maximum rated speed.

d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.

4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully OPEN.
2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 10 percent.
3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

3.03 ADJUSTING AND BALANCING WATER SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
   a. Review Shop Drawings and installed system for adequate and accessible balancing devices and test ports.
   b. Recommend to Engineer devices needed to be added or replaced in order to obtain proper water control.
   c. Verify proper startup procedures have been completed on system.
   d. Verify controls installation is complete and system is in stable operation under automatic control.
   e. Verify hydronic systems have been filled and are clean. Examine a sample of strainers to ensure cleanliness.
   f. Verify manual air vents have been bled and expansion tanks and automatic air vents are functioning.
   g. Verify control valves and coil connections are complete and properly installed.

B. General:

1. When adjustments are made to a portion of a water system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Correctly adjust water flow readings for mixtures other than pure water.
3. Throttling of butterfly and other non-balancing device valves shall not be allowed.
4. Lock and mark final positions of balancing devices with a centerpunch or permanent felt pen.

C. Equipment Data:

1. Collect the following data and include in final report:
   a. Type of pump.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, impeller size and serial number).
   d. Pump capacity (flow rate and differential pressure).
   e. Drive data.
   f. Motor data (frame, hp, volts, FLA rpm, and service factor).
   g. Starter and motor overload protection data.
   h. Include changes made during course of system balancing.

D. Pumps:

1. Verify impeller size through a “dead-head” test. Do not perform on positive displacement pumps.
2. Adjust water to achieve design flows at all modes of operation during single and multiple pump operation.
3. Test redundant and stand-by pumps.
4. After final adjustments, do not operate motor above nameplate amperage on any phase.
5. Read and record pressures at pump inlet and discharge for each test condition.
6. Read and record motor amperage on all phases for each test condition.
7. Record and mark final position of balancing cocks, valves, and operators with a permanent felt pen or centerpunch.

E. Terminal Flow Devices:

1. Adjust water systems for required flow rates at each coil, connection, and terminal device.
2. Provide proper flow through individual fin tube sections, evaporator and condenser circuits, each boiler loop, each pump, and recirculation loops.

3. Measure and adjust flow through valves and valve bypass lines.
4. Record and mark final position of balancing cocks, valves, and operators with a permanent felt pen or centerpunch.
5. Read and record differential pressures across coils, control valves, chiller bundles, boilers, and heat exchanges.

F. Tolerances:

1. Heating Water Flow Rate: Plus 10 percent to minus 10 percent.
2. Nonpotable Hot Recirculation Water Flow Rate: Plus 10 percent to minus 10 percent.

3.04 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01756, Testing and Facility Startup.

B. Performance Testing:

1. Heating or Sensible Cooling Coil Testing:
   a. Adjust system as required to achieve design flow conditions for both air and water sides of coil.
   b. Measure and record airflow rate, water flow rate, entering air temperature, entering water temperature, leaving air temperature and leaving water temperature.
2. Cooling or Dehumidification Coil Testing:
   a. Adjust system as required to achieve design flow conditions for both air and water sides of coil.
   b. Measure and record airflow rate, water flow rate, entering air dry bulb and wet bulb temperatures, entering water temperature, leaving air dry bulb and wet bulb temperatures and leaving water temperature.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.

6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
   a. Air and water balancing procedures, vibration tests, and verification of test results.
   b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building, and on 10 percent of total water balance fittings, with measuring equipment used in original tests, at random points selected by Engineer.
   c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
   d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

SECTION 15955
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
   a. Submit prior to testing and include at least the information that follows.
      1) Testing dates.
      2) Piping systems and section(s) to be tested.
      3) Test type.
      4) Method of isolation.
      5) Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
4. New Piping Connected to Existing Piping:
   a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.

b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.

5. Test Pressure: As indicated on Piping Schedule located on the Drawings.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:

1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Where specified on the Piping Schedule as shown on the Drawings.

B. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

C. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning or disinfection.

D. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.

4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{148{,}000}$$

where:

L = Allowable leakage, in gallons per hour.
S = Length of pipe tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Where specified on the Piping Schedule as shown on the Drawings.

B. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 18 inches.
3. Buried and other non-exposed piping.

C. Fluid: Oil-free, dry air.

D. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

E. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

F. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Where specified on the Piping Schedule as shown on the Drawings.

B. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

C. Maximum Allowable Leakage: 0.16 gallon(s) per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

D. Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.

E. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

F. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

G. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

H. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 16050
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. General requirements applicable to all Electrical Work.
2. General requirements for Electrical Submittals.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. This section shall be applicable to all Division 16, Electrical specifications.
3. It is the Contractor’s responsibility to schedule and coordinate the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

C. Interfaces to Equipment, Instruments, and Other Components:

1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
    a. Make all changes necessary to meet the manufacturer’s wiring requirements.
3. Submit all such changes and additions to the Engineer for acceptance as specified in the General Conditions.

4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
    a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
5. Loop Drawings:
    a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
        1) Conduit numbers and associated signal(s) contained within each conduit.
        2) Wire numbers.
        3) Equipment terminal numbers.
        4) Junction boxes and signal(s) contained within each junction box.
        5) Equipment power sources, and associated circuit numbers.
        6) As-built drawings detailing wiring.

D. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:

1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections, including HVAC controls, packaged mechanical systems, Local Control Panels (LCPs), Vendor Control Panel (VCPs), etc.
2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

E. Special Subcontractor Requirements: As specified elsewhere in this section, provide the Work specified in the Electrical Specifications by a qualified electrical subcontractor.

F. Contract Documents:

1. General: The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.

2. Specifications:
   a. The General and Supplementary Conditions of the Contract Documents govern the Work.
   b. These requirements are in addition to all General Requirements.
3. Contract Drawings:
   a. The Electrical and Instrumentation Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
   b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
      1) The equipment locations and dimensions as indicated on the Drawings are approximate. Use Shop Drawings to determine the proper layout, foundation, pad requirements, and all conduit entrances from top or bottom to ensure those will align with the interior equipment layout, etc., for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
      2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space and not confirmed all interconnection power and control wiring for the actual furnished manufacturer. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
   c. Installation Details:
      1) Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      2) Not all typical installation details are referenced within Drawing set. Apply and use typical details where appropriate.
   d. Schematic Diagrams:
      1) All controls are shown de-energized.
      2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

3) Add additional relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

1.02 REFERENCES

A. Code Compliance:

1. As specified in Section 01410, Permits and Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this section.
   a. American National Standards Institute (ANSI).
   b. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
   c. ASTM International (ASTM).
   d. Illuminating Engineering Society (IES).
   e. Institute of Electrical and Electronics Engineers (IEEE).
   f. Insulated Cable Engineers Association (ICEA).
   g. International Code Council (ICC): International Code Council Evaluation Service (ICC-ES): AC 156, Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
   h. International Society of Automation (ISA).
   i. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 V Maximum).
   j. National Fire Protection Association (NFPA): 70, National Electric Code (NEC).
   k. National Institute of Standards and Technology (NIST).
   l. UL.

B. Compliance with Laws and Regulations: As specified in the General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. IES.
3. ISA.
4. NEC.
5. NEMA.
6. NETA.
7. NFPA.
8. NIST.

B. Specific Definitions:

1. Factory Acceptance Test (FAT).
2. Instrumentation and Controls Subcontractor (ICSC).
3. Local Control Panel (LCP): Operator interface panel that may contain an HMI (Human Machine Interface), pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC (Programmable Logic Controller), RTU (Remote Telemetry Unit) or RIO (Remote Input/Output).
4. Local Control Station (LCS): Operator interface panel that may contain pilot type control devices, operator interface devices, etc.
5. Process Control Module (PCM):
    a. An enclosure containing any of the following devices:
        1) PLC, RTU, or RIO.
6. Process Control and Instrumentation System (PCIS).
7. Remote Telemetry Unit (RTU): A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
8. Space: That portion of the switchgear, motor control center (MCC), panel-board, switchboard or control panel that does not physically contain a device, but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
9. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
10. System Supplier: Refer to Quality Assurance in this section.

11. Vendor Control Panel (VCP): Control panels that are furnished with equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT (Operator Interface Terminal), HMI, etc.
12. Unequipped Space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General Requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work as indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
   a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work, including heating, ventilating, and air conditioning.
4. Coordinate all aspects of the Work with the electrical Subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical Subcontractor, the other Subcontractors or Suppliers.
5. Demolition:
   a. Where demolition is specified or as indicated on the Drawings, disconnect all associated electrical equipment, and render the equipment safe.
   b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   c. Salvage electrical equipment as indicated on the Drawings.

d. For each piece of equipment to be removed, remove all ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
e. Conduit:
    1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
        a) Remove exposed conduit completely to source. For conduits that are partially concealed in concrete or below grade, remove exposed conduit to the point of encasement or burial.
        b) Cut conduit flush and plug or cap encased or buried conduit.
    2) Where conduits are to remain in place and removal is not indicated on the Drawings:
        a) Cap conduit open ends.
        b) Re-label empty conduits as spare.
f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
h. Provide new typed panel schedules for all new panelboards. Provide marked up district panel schedule to inspector whenever modifying existing panelboards.
i. Provide Knock out (KO) seals in all penetrations in enclosures and equipment that are made available by the removal of conduits or raceways.
j. Seal all penetrations in walls and floors that are made available by the removal of conduits or raceways. Grout fill all penetrations in concrete.

6. Some Projects involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
    b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
7. Do not penetrate existing enclosures, control panels, or equipment without the Owner present to observe the installation. The Owner shall observe the Contractor while these penetrations are created.

8. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation as specified in the Contract Documents.
9. Defective Work: As contained in Article 15 of the General Conditions.

B. Operating Facility:

1. As specified in Section 01140, Work Restrictions.
2. The Digester Complex 1, Digester Complex 2, and FOG facilities are operating facilities. Portions of these facilities must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
   a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
   b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
   c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and this section.

B. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this section.
2. Furnish the submittals required by each section in the Electrical Specifications.

3. Adhere to the wiring numbering scheme specified in Section 16075, Electrical Identification, throughout the Project:
   a. Uniquely number each wire.
   b. Wire numbers must appear on all Equipment Drawings.
4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
5. List of manufacturer's recommended spare parts.

C. Seismic Requirements:

1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.
2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
   a. Statement of Seismic Qualification, and Special Seismic Certification:
      1) Statement of Seismic Qualification: Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410, Permits and Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
      2) Special Seismic Certification: Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with Ip equals 1.5." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
   b. Substantiating Test Data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
   c. Anchoring Design Calculations and Details: Submit project-specific drawings and supporting calculations, prepared, and sealed by a professional engineer licensed in the State of Oregon, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612, Anchorage and Bracing.

3. Exemptions:
    a. A “statement of seismic qualification” and a “special seismic certification” are not required for the following equipment:
        1) Temporary or moveable equipment.
        2) Equipment anchored to the structure and having a total weight of 20 pounds or less.
        3) Distribution equipment anchored to the structure and having a total unit weight of 5 pounds per linear foot, or less.

D. Submittal Organization:

1. First Page:
    a. Specification section reference.
    b. Name and telephone number of individuals who reviewed submittal before delivery to Engineer.
    c. Name and telephone number of person who is primarily responsible for the development of the submittal.
    d. Place for Contractor’s review stamp and comments.
2. Next Pages:
    a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
    b. Include a response in writing to each of the Engineer’s comments or questions for submittal packages which are re-submitted:
        1) In the order that the comments or questions were presented throughout the submittal.
        2) Referenced by index section and page number on which the comment appeared.
        3) Acceptable responses to Engineer’s comments are either:
            a) Engineer’s comment or change is accepted, and appropriate changes are made.
            b) Explain why comment is not accepted or requested change is not made.
            c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
        4) Any re-submittal, which does not contain responses to the Engineer’s previous comments shall be returned for Revision and Re-submittal.
        5) No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining Pages:
    a. Actual Submittal Data:
        1) Organize submittals in the same order as the items are referenced, listed, and/or organized in the specification section.
        2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal Requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals, so that the submittal specifically applies to only the equipment furnished.
    a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
    b. Highlight in yellow all part numbers used.
4. Submit Copies of Shop Drawings, and Product Data: Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than one submittal per specification section, but a single submittal may not cover more than one specification section:
    a. The only exception to this requirement is when one specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section).
6. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.

c. Acceptance of any exception is at the sole discretion of the Engineer. Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

7. Specific Submittal Requirements:
   a. Shop Drawings:
      1) Required for materials and equipment listed in this and other sections.
      2) Furnish enough information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these specifications.
      3) Shop Drawings Requirements:
         a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
         b) Locations of conduit entrances and access plates.
         c) Component layout and identification.
         d) Schematic and wiring diagrams with wire numbers and terminal identification.
         e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
         f) Anchoring method and leveling criteria, including manufacturer’s recommendations for the Project Site seismic criteria.
         g) Weight.
         h) Finish.
         i) Nameplates: As specified in Section 16075, Electrical Identification.
         j) Temperature limitations, as applicable.
   b. Product Data:
      1) Submitted for non-custom manufactured material listed in this and other sections and shown on the Shop Drawings.
      2) Include:
         a) Catalog cut sheets.
         b) Bulletins.
         c) Brochures.
         d) Quality photocopies of applicable pages from these documents.
         e) Identify on the data sheets the Project name, applicable specification section, and paragraph.

f) Identify model number and options for the actual equipment being furnished.
g) Neatly cross out options that do not apply or equipment not intended to be supplied.
h) Highlight in yellow all part numbers.

c. Detailed sequence of operation for all equipment or systems.

F. Operation and Maintenance Manuals: As specified in Section 01782, Operation and Maintenance Data.

G. Material and Equipment Schedules:

1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use: Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

H. Roof Penetrations: Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

I. Record Documents:

1. Furnish as specified in Section 01770, Closeout Procedures.
2. Provide Record Documents of all Electrical Drawings.
3. Record Drawing Requirements:
   a. Update Record Drawings weekly.
   b. Record Drawings must be fully updated as a condition of the monthly progress payments.
   c. Submit Record Drawings upon completion of the Work for final review.
   d. Clearly and neatly show all changes, including the following:
      1) All existing pipe, conduit, wire, instruments, or other structures encountered or uncovered during construction.
4. Shop Drawings:
   a. Upon completion of the Work, update all Shop Drawings to indicate the final as-built configuration of the systems:
      1) Provide as-built Shop Drawings for all electrical equipment on 11-inch by 17-inch bond paper.
      2) Provide electronic copies of these documents on in AutoCAD by Autodesk and PDF. Verify the current version of AutoCAD with the District. Size all drawings to be readable and legible on 11-inch by 17-inch media.

b. Furnish written information prepared specifically for this Project using Microsoft Word and PDF: Provide electronic copies of these documents.

5. Review and Corrections:
   a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   b. Promptly correct and re-submit record documents returned for correction.

J. Test Reports:

1. As specified in Section 01330, Submittal Procedures.
2. Include the following:
   a. A description of the test.
   b. List of equipment used.
   c. Name of the person conducting the test.
   d. Date and time the test was conducted.
   e. All raw data collected.
   f. Calculated results.
   g. Each report signed by the person responsible for the test.
3. Additional requirements for acceptance test reports are specified in Section 16950, Field Electrical Acceptance Tests.

K. Calculations:

1. Where required by specific Electrical Specifications: These calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

L. Factory Acceptance Test:

1. As specified in Section 01330, Submittal Procedures.
2. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL, CSA TUV, or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

B. System Supplier Responsibilities:

1. Requirements as specified in the Instrumentation and Control Specifications.
2. System Supplier:
   a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and Instrumentation and Control Specifications, and shown on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.
3. Contractual Relationship:
   a. Form a contractual relationship between the electrical subcontractor and the ICSC.
   b. Requirements for the First-tier Subcontractor:
      1) Contract directly with the Contractor.
      2) Be either the electrical subcontractor or the ICSC.
   c. Requirements for the Second-tier Subcontractor:
      1) A division of the first-tier subcontractor.
      2) A joint venture with the first-tier subcontractor.
      3) A subcontractor to the first-tier subcontractor.
   d. The system supplier manages, directs, and supervises all the Work of its second-tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system, including, but not limited to, all Electrical, Instrumentation, and Process Drawings, Electrical Specifications, and Instrumentation and Control Specifications:
      1) Provide any additional conduit, wire, etc.
      2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
      3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Shipping Precautions:

1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty

polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
2. Place dehumidifiers, when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the Job Site.

B. Delivery and Inspection: Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

C. Special Instructions: Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.08 PROJECT OR SITE CONDITIONS

A. Site Conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
2. Seismic Load Resistance: Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.
3. Wind Load Resistance: Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01612, Anchorage and Bracing.
4. Altitude, Temperature, and Humidity:
   a. Elevation: 155.
      1) Ambient Air Temperature: 23 degrees F to 95 degrees F.
      2) Ambient Air RH: 10 percent to 90 percent.
   b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional de-rating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees F above the minimum operating temperature and 10 degrees F below

maximum operating temperature, as determined by the equipment manufacturer's guidelines:

1) Provide all power conduits wiring for these devices (e.g., heaters, fans, etc.) whether indicated on the Drawings or not.

5. Site Security: Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329, Safety Plan.
6. Outdoor Installations:
   a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
   b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation, and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this section for the following equipment:
      1) Provide all wiring necessary to power these devices.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA 250 for the following types of enclosures:

1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
3. NEMA Type 4X: Made from corrosion resistant materials (Type 316 stainless steel) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
4. NEMA Type 6: Rated for submergence.
5. NEMA Type 6P: Rated for prolonged submergence.
6. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I, Division 1 or Class I, Division 2) meeting the requirements outlined in Section 16052, Hazardous Classified Area Construction.
7. NEMA Type 8: Intended for installation in either indoor or outdoor locations where explosive or combustible gas or vapors may be present (Class I, Division 1 or Class I, Division 2), and the equipment is oil-immersed, meeting the requirements outlined in Section 16052, Hazardous Classified Area Construction.
8. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

C. Plant Area Electrical Work Requirements:

1. Provide all Electrical Work in accordance with the Area Classification and Materials Selection Table, located on the Drawings.
2. Provide stainless steel NEMA 4X enclosures and supports, and Rigid Aluminum Conduit (RAC) conduit type for all Electrical work not included in the Area Classification and Materials Selection Table, on the Drawings. Conduit type definitions are listed under Section 16130, Conduits, and also in the Area Classification and Materials Selection Table.
3. Modify conduit runs as specified in Section 16130, Conduits.

1.09 WIRING WITHIN CONDUIT

A. All wiring shall be installed within a conduit, raceway, or tray as identified within Contract Documents, no exceptions.

1. All wiring associated with low voltage systems including, but not limited to, low voltage communications, electronic access control, building automation/HVAC control, security systems, and fire alarm systems shall be in conduit, no exceptions.
2. All Class II wiring shall be within conduit, no exceptions.

1.10 SCHEDULING

A. General:

1. General scheduling requirements are specified in Section 01324, Construction Schedule.
2. Work restrictions and other scheduling requirements are specified in Section 01140, Work Restrictions.
3. The Contractor shall complete and submit a Deactivation Request Form prior to de-energizing any electrical equipment. The Form shall be furnished to the Contractor by the District.
4. Testing and process Start-up requirements as specified in Section 01756, Testing and Facility Startup.

B. Pre-submittal Conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, all suppliers, and individual equipment manufacturers

furnishing major pieces of equipment must attend including, but not limited to:

a. Vendor control panels.
b. Electrical equipment shelter.
c. Local control stations.
d. Disconnect switches.
e. Variable frequency drives.
f. Lighting.

3. The Contractor shall produce a copy of the electrical permit at the pre-submittal conference.

C. Factory Acceptance Testing:

1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
   a. Indicate the desired dates for inspection and testing.
   b. Schedule the FAT after approval of the FAT procedure's submittal:
      1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
      2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work: Shall be in accordance with the General Conditions, provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM STARTUP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard in accordance with the General Conditions.

2.03 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

B. Arrange with all manufacturers of the electrical equipment, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:

1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.

C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. The electrical subcontractor is encouraged to examine the premises completely before bidding.

B. The electrical subcontractor shall examine the bid documents completely before bidding.

C. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

D. Review the Site conditions and examine all Shop Drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

E. Provide a Complete Electrical System: Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, PCIS, and HVAC system.

3.02 INSTALLATION

A. Equipment locations shown on the Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:

1. Verify all dimensions as indicated on the Drawings: Actual field conditions govern all final installed locations, distances, and levels.
2. Review all Contract Documents and approved equipment Shop Drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
4. Provide a Complete Electrical System: Install all extra conduits, all breaker hardware, cables, and interfaces as may be necessary to provide a complete and operational electrical, PCIS, and HVAC system.

B. Submit a Request for Information for any conflict between Drawings and Specifications prior to installation.

C. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

D. Cutting and Patching:

1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
    a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting, or piercing:
        1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use GPR(Ground Penetrating Radar)or X-ray to ensure that area is clear of obstructions.
    b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
    a. 3M; CP 25WB+, Caulk.
    b. 3M; Fire Barrier, Putty.
3. Seal around conduit penetrations of belowgrade walls with a waterproof, nonshrink, nonmetallic grout, unless otherwise indicated on the typical installation details:
    a. Use the installation details as indicated on the Drawings as a guide for acceptable sealing methods.

E. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:

1. Install all conduits and equipment in accordance with working space requirements as outlined in the NEC.
    a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
2. Where Drawings do not show dimensions for locating equipment, install equipment in the approximate locations as indicated on the Drawings. Adjust equipment locations as necessary to avoid any obstruction or interferences.
3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.

4. Where Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods like the mounting details as indicated on the Drawings.

F. Conduit Support Straps: Conduit straps shall be of the same material as the conduit, if not otherwise specified.

G. Earthwork and Concrete: Install all trenching, shoring, concrete, backfilling, grading, and resurfacing associated with the Electrical Work:

1. Requirements as specified in the Contract Documents.

H. Roof Penetrations: Seal conduit penetrations in accordance with roofing manufacturer's instructions.

I. Terminations: Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

1. Coat all aluminum lugs thread with a UL listed Petroleum base Oxide Inhibitor.
   a. DE-OX, Ilsco.

J. Handholes:

1. Conduits shall angle away from vaults, down into handholes where possible.
2. Handholes shall not be placed in areas where water collection onsite is possible, unless absolutely necessary and secondary means to dewater the unit are in place.
3. Handholes shall have positive drainage and check valve in place to prevent back leakage and groundwater inflow.

K. Miscellaneous Installation Requirements:

1. In case of interference between electrical equipment as indicated on the Drawings and the other equipment, notify the Engineer as specified in the General Conditions.
2. Location of handholes and pull-boxes as indicated on the Drawings are approximate. Coordinate exact location of handholes and pull-boxes with Mechanical and Civil Work.
3. Provide additional conduit bodies to those shown where they are required to make a workable installation.

L. Labeling:

1. Provide all nameplates and labels as specified in Section 16075, Electrical Identification.
2. Label all junction and pull boxes.

M. Equipment Tie-downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
2. All control panels, VCPs, LCPs, RTUs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.03 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

B. For Owner and Engineer Witnessed Field Acceptance Test (FAT): The Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in individual equipment sections.

3.04 FIELD QUALITY CONTROL

A. Inspection:

1. Allow for inspection of electrical system installation as specified in Section 01451, Special Inspection, Observation, and Testing.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with the Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect raceway installation for quality workmanship and adequate support.
    g. Inspect cable terminations.
    h. Schedule inspection of all mounting of electrical devices and all penetration and connections to structures.

4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950, Field Electrical Acceptance Tests.

B. Field Testing:

1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the acceptance tests as specified in Section 16950, Field Electrical Acceptance Tests.
3. Record Results of the Required Tests Along with the Date of Test: Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:

1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
   a. Neatly coil and label spare wiring lengths.
   b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Owner.
   c. All spare conductors shall be labeled individually.
      1) The source of the spare conductor(s) shall be labeled at the destination.
      2) The destination of the spare conductors(s) shall be labeled at the source.

3.05 CLEANING

A. As specified in Section 01770, Closeout Procedures.

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:

1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean the electrical rooms prior to completion. Clean the floors, tops of enclosures, and cable trays of all debris, dirt, and dust.

E. As specified in other sections of the Contract Documents.

3.06 DEMONSTRATION AND TRAINING

A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections.

3.07 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

END OF SECTION

SECTION 16052
HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. As specified in Section 16050, Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions: For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

1.05 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
   a. Except as modified in Article 500 through Article 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
   b. All devices used in Class I, Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 PROJECT OR SITE CONDITIONS

A. A list of hazardous areas is shown on the Area Classification and Materials Selection Table on the Drawings.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Conduit and Sealing Fittings: As specified in Section 16130, Conduits.

B. Conduit Boxes and Bodies: As specified in Section 16134, Boxes.

C. Wiring Devices: As specified in Section 16140, Wiring Devices.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Conduit Installation:

1. As specified in Section 16130, Conduits.
2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.

3. Make all conduit connections so that there is a minimum of 5 threads fully engaged in the connection.
4. Flexible Conduit:
   a. Class I, Division 1 Hazardous Areas:
      1) Approved and marked suitable for Class I, Division 1.
      2) Listed for compatibility with the group type atmosphere where used.
   b. Class I, Division 2 Areas: Liquid tight metal conduit with approved fittings.
   c. Maximum length as specified in Section 16130, Conduits.

C. Sealing Fittings:

1. Provide an approved seal, no more than 18 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
   a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies like “L,” “T,” and “X” may be installed between the sealing fitting and the enclosure.
2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
   a. Seals are required in all conduit connections to the compartment containing splices and must be within 18 inches of the enclosure.
3. Install a conduit seal within 18 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
4. For underground conduits entering or leaving a classified location or between Class I, Division 1 and Division 2 locations:
   a. Provide a conduit seal at both points where the conduit emerges from the ground:
      1) Place the conduit seal within 18 inches of finished grade.
      2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.

5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
   a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
8. All electrical equipment shall have a union installed between the seal and the respective motor, actuator, or instrument transmitter. This will permit the motor, actuator, or transmitter to be disconnected or replaced without disturbing the wiring or conduit seal.

D. Boxes and Fittings:

1. Class I, Division 1 Areas: Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
2. Class I, Division 2 Areas: Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.

E. Outlet Boxes and Bodies:

1. Provide conduits bodies and boxes suitable for the conduit system as specified in Section 16130, Conduits.
2. Class I, Division 2 Areas:
   a. Boxes Not Containing Arcing Parts:
      1) Material and NEMA ratings as specified in Section 16050, Common Work Results for Electrical.
      2) Pressed metal boxes are not allowed.
   b. Provide heavy duty cast construction type conduit fittings and joints: Explosion proof rated fittings and joints are not necessary.
   c. Any enclosure containing arcing parts, etc., shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I, Division 1 construction.

F. Motor Connections:

1. Conduit installation in Class I, Division 1 and Class I, Division 2 locations for motors that contain arcing parts, shall proceed as follows:
   a. First: Conduit.
   b. Second: Explosion proof flexible coupling.

c. Third: Sealing fitting.
d. Fourth: Explosion proof union.
e. Fifth: Connection to the motor terminal box.

2. Wiring connections to motor leads shall be as specified in Section 16150, Low Voltage Wire Connections.
3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

G. Grounding: A grounding conductor shall be provided in all raceways, junction boxes, and enclosures located within all Class 1, Division 1 and Class 1, Division 2 locations.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Obtain inspection and approval from the Engineer before and after each seal is poured.

END OF SECTION

SECTION 16055
PIPE HEAT TRACING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. UL.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 50 degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 15080, Process Piping Insulation, pipe as specified in Section 15200, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, Fiberglass Reinforced Plastic (FRP), and stainless steel pipe applications.

B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Manufacturers and Products:

1. Splice Kit:
   a. Raychem; S-150.
   b. Thermon; PCS-1-SR.
   c. Nelson; PLT-BS.
2. Tee Kit:
   a. Raychem; T-100.
   b. Thermon; DS-S.
   c. Nelson; PLT-BY.
3. End Seal Kit:
   a. Raychem; E-150.
   b. Thermon; DE-S.
   c. Nelson; LT-ME.

C. Provide products with suitable ratings where located in Class 2, Division 1 or Division 2 areas.

2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
   a. Raychem; AT-180.
   b. Thermon; AL-20P.
   c. Nelson; AT-50.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
   a. Raychem; GS54 or GT66.
   b. Thermon; PF-1.
   c. Nelson; GT-6 or GT-60.

2.05 HEAT TRACE CONTROL BOX

A. 12 inch wide by 12 inch tall by 6 inch deep NEMA 1 enclosure:

1. Wall mounted.
2. Hinged door.

B. Electrically Held Contactor:

1. UL listed.
2. Electrically operated, electrically held.
3. Main Contacts:
   a. Power driven in one direction with mechanical spring dropout.
   b. Silber alloy with wiping action and arc quenchers.
   c. Continuous duty rated 20 amperes.
   d. Poles: Two.

C. Control: Two-wire.

1. Control Relay:
   a. Connection to PLC for control.
   b. Located within the heat trace control box.

D. Power: 120V single phase power.

E. Auxiliary Contacts: One normally open and one normally closed, rated 7,200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Manufacturer and Product: Eaton; C30CNE20A0.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Provide insulation as specified in Section 15080, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.
4. Install on services as follows:

Service	Piping Material	Placement	Location
NPW	PVC	REFER TO ELECTRICAL DRAWINGS	Outdoors

5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Bolted flanges (per pair)	Two times pipe diameter
Valves	Four times valve length

Item	Heating Tape Length (min. feet)
Pipe hanger or support penetrating insulation	Three times pipe diameter

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

SECTION 16060
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Grounding electrodes.
2. Grounding electrode conductors.
3. Equipment grounding conductors.
4. Ground connections.
5. General requirements for grounding.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. B3, Standard Specification for Soft or Annealed Copper Wire.
   b. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
3. Institute of Electrical and Electronics Engineers (IEEE):81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
4. UL: 467, Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:

1. Ground electrodes.
2. Bonding jumpers.
3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950, Field Electrical Acceptance Tests, shall be:

1. 5 ohms or less for industrial systems.
2. 1 ohm or less for electrical buildings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data: Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression Connectors:

1. One of the following:
   a. FCI Burndy.
   b. Thomas & Betts.
   c. “Or-equal.”

B. Ground Rods:

1. One of the following:
   a. Erico.
   b. Harger.
   c. Conex.
   d. “Or-equal.”

C. Ground Cable:

1. One of the following:
   a. Nehring.
   b. Harger.
   c. Southwire.
   d. “Or-equal.”

D. Precast Ground Well Boxes:

1. One of the following:
   a. Brooks Products, 3-RT Valve Box.
   b. Christy Concrete Products, G12 Valve Box.
   c. “Or-equal.”

2.02 MATERIALS

A. Ground Rod:

1. Minimum: 3/4-inch diameter, 10 feet long.
2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core: The copper-to-steel bond shall be corrosion resistant.
3. In accordance with UL 467.
4. Sectional type joined by threaded copper alloy couplings.
5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground Cable:

1. Requirements:
   a. Soft drawn (annealed).
   b. Concentric lay, coarse stranded in accordance with ASTM B8.
   c. Bare copper in accordance with ASTM B3.
2. Size is as indicated on the Drawings, but not less than required by the NEC.
3. Every wiring method shall have a dedicated equipment grounding conductor.

C. Compression Connectors:

1. Manufactured of high copper alloy specifically for the grounding application.
2. Suitable for direct burial in earth and concrete.
3. Identifying compression die number inscription to be impressed on compression fitting.
4. Exothermic (Cadweld) welding is not allowed.

D. Equipment Grounding Conductors:

1. Conductors shall be the same type and insulation as the load circuit conductors: Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
2. Minimum size in accordance with the NEC, or larger if indicated on the Drawings.

E. Grounding Electrode Conductors: Minimum size in accordance with the NEC.

F. Main Bonding Jumpers and Bonding Jumpers: Minimum size in accordance with the NEC.

G. Ground Bus/Interstitial Bus:

1. Provide accessible copper grounding bus bar, 16-inch-long with insulators in main electrical room.
   a. Hubbell, HBBB14416H.

2.03 ACCESSORIES

A. Precast Ground Well Boxes:

1. Minimum 10-inch interior diameter.
2. Traffic-rated cast iron cover.
3. Permanent “GROUND” marking on cover.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:

1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:

1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:

1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lug for a connection to a grounding conductor for all conduits which terminate at a cable tray.

F. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

G. Provide a green insulated grounding wire jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

H. Ground conductors passing through concrete structure shall run through a PVC sleeve within and completely through the concrete. Where there is a risk of tripping PVC sleeves shall continue to connection point.

I. Ground Connections:

1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression

type grounding connectors as indicated on the Drawings, UL, CSA, or TUV listed, and labeled for the application.

2. Make ground connections in accordance with the manufacturer's instructions.
3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
4. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
5. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
6. Bond all metallic equipment likely to become energized.

J. Grounding Electrode System:

1. Ground Rods:
   a. Location as indicated on the Drawings.
   b. Length of rods forming an individual ground array shall be equal in length.
   c. Drive ground rods and install grounding conductors before constriction on concrete slabs and duct banks.
   d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
2. Ground Ring:
   a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
   b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
   c. Minimum burial depth 36 inches or as indicated on the Drawings.
   d. Re-compact disturbed soils to original density in 6-inch lifts.
   e. Size shall be minimum required by NEC or as shown on the Drawings, whichever is larger.

K. Shield Grounding:

1. Shielded instrumentation cable shall have its shield grounded at one end only unless Shop Drawings indicate otherwise:
   a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
2. Terminate the shield drain wire on a dedicated terminal block.
3. Insulate the non-grounding end of the shielded cable.

4. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
5. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

L. Where indicated on the Drawings, install ground rods in precast ground wells.

M. All grounding conductors inside control panels and control cabinets shall be insulated.

N. All grounding conductors shall be insulated Green or Green with yellow strip is acceptable.

O. When connecting to an existing grounding system, it is contractor’s responsibility to ensure existing system is built to code.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16070
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Mounting and supporting electrical equipment and components.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

A. Trapeze: 6 or more conduits.

B. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:

1. Conform to the requirements of the Building Code as specified in Section 01410, Permits and Regulatory Requirements.

2. Demonstrate the following using generally accepted engineering methods:
   a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
   b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
3. Design Loading and Anchoring Requirements:
   a. As indicated in the Building Code unless otherwise specified.
   b. Seismic Loading Requirements: Freestanding or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050, Common Work Results for Electrical.
   c. Wind Loading Requirements: All exterior freestanding equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050, Common Work Results for Electrical.
   d. Minimum Safety Factor Against Overturning: 1.5.
   e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.
   f. Size the supports for conduit racks and trapezes with 40 percent spare capacity of the largest raceway on the rack or trapeze.

B. Performance Requirements: Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Supports:
   a. Materials.
   b. Geometry.
   c. Manufacturer.
2. Hardware:
   a. Materials.
   b. Manufacturer.

C. Shop Drawings:

1. Complete dimensioned and scalable Shop Drawings of all supporting structures, trapezes, wall supports, etc.
2. Complete anchoring details for equipment, lighting, and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
   a. Stamped by a professional engineer licensed in the State of Oregon.
   b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.

D. Installation Instructions:

1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
   a. Stamped by a professional engineer licensed in the state of Oregon.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Thomas & Betts.
2. Power-Strut.
3. Unistrut.
4. Cooper B-Line.
5. Robroy.
6. Aickinstrut.
7. “Or-equal.”

2.02 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

B. Stainless Steel:

1. Supports:
   a. In accordance with ASTM A240.
   b. ANSI Type 316 material.
   c. Minimum Size: 1-5/8 inches by 1-5/8 inches.
2. Hardware: ANSI Type 316 material.

C. PVC Coated Galvanized Steel:

1. Supports:
   a. Hot dip galvanized steel as specified in this section.
   b. PVC coating thickness of 10 mils to 20 mils.
   c. Minimum Size: 1-5/8 inches by 1-5/8 inches.
2. Hardware: ANSI Type 316 material.

2.03 ACCESSORIES

A. Anchor bolts: ANSI Type 316 material.

2.04 FINISHES

A. Paint and finish all supporting structures as specified in Section 09900, Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.

1. Provide the necessary sway bracing to keep trapeze type structures from swaying.

C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:

1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.

D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:

1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

E. Corrosion Protection: Isolate dissimilar metals, except where required for electrical continuity. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

F. Raceway:

1. Furnish all conduit racks and trapeze structures needed to support the raceway from the structure.
   a. Group conduits and position on racks to minimize crossovers.
   b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
2. Conduit racks and trapeze structures shall be sized with 40 percent spare capacity of the largest conduit installed on the rack or trapeze units.

G. Anchoring Methods:

1. Solid Concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05500, Metal Fabrications.
2. Metal Surfaces: Machine screws or bolts.
3. Hollow Masonry Units: Post-installed anchors as specified in Section 05500, Metal Fabrications.

H. When supporting devices on metal or wood stud construction, provide a Listed steel bracket for supporting boxes. All boxes at the same elevation within a stud bay shall be supported by the same bracket.

I. Re-coat all scratches, cuts, and drilled holes in galvanized surfaces with CRC “Zinc-It” or similar product.

J. Re-coat all drilled holes and cut surfaces on PVC-coated materials.

K. Seal all drilled holes and cut surfaces on fiberglass materials.

L. Use manufacturer supplied strut splice clevises where two or more pieces of strut are joined.

M. Provide white strut plastic end caps on the ends of all struts. End caps shall cover exposed edges of strut.

N. Threaded rods shall not protrude more than 1/2 inch beyond the last nut.

O. Where not called out, conduit straps shall be of the same material as the conduit it is holding.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16075
ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. Identifying electrical, instrumentation, and process equipment and components.
2. Material, manufacturing, and installation requirements for identification devices.

B. Related Specifications:

1. Section 01330, Submittal Procedures.
2. Division 15, Mechanical.
3. Division 16, Electrical.
4. Division 17, Process Instrumentation and Controls.

1.02 REFERENCES

A. Refer to Section 16050, Common Work Results for Electrical.

1.03 DEFINITIONS

A. Refer to Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Nameplates:

1. Provide a nameplate for each piece of mechanical equipment, process equipment, valve, pump, mixer, feeder, fan, air-handling unit, motor, switch, receptacle, controller, instrument transducer, instrument power supply, solenoid, motor control center, starter, panelboard, switchboard, individually mounted or plug-in type circuit protector or motor controller, disconnect switch, bus duct tap switch, time switch, relay and for any other control device or major item of electrical equipment, either located in the field or within panels.
2. Provide all nameplates of identical style, color, and material throughout the facility.
3. Provide new nameplates for all existing equipment worked on in this Project.

B. Wire Numbers:

1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
   a. Control and Instrumentation wires and cables shall be assigned a unique identification number following Owner standards.
   b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
   c. Internal panel wires on a common terminal shall have the same wire number.
   d. Multiconductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
      1) Label armored multiconductor cable using the conduit number following the requirements for conduit markers as described within this specification, except conduit markers shall only be required at the source and the destination.
      2) All spare conductors shall be individually labeled. Label the destination at the source and label the source at the destination.
      3) Spare wiring and terminals shall be tagged as spares.
2. Power cables and wires shall be assigned a unique identification number as specified by Owner.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Use excel file provided by District in accordance with Supplement Tagging Submittal following end of section.

C. Product Data:

1. Nameplates:
   a. Color.
   b. Size:
      1) Outside dimensions.
      2) Lettering.
   c. Material.
   d. Mounting means.

2. Equipment Nameplate Schedule:
   a. Show exact wording for each nameplate.
   b. Include nameplate and letter sizes.
   c. Schedule format shall match equipment nameplate schedule attached at the end of this section.
   d. Submit equipment nameplate schedule for approval before engraving nameplates.
3. Wire Numbers: Manufacturer's catalog data for wire labels and label printer.
4. The Contractor shall submit samples for each type of Electrical Identification device intended to be provided for this Project for review and approval. Samples of the materials and colors proposed for the work and application instructions shall be included. Devices shall indicate proposed text sizes, lettering and background coloring and related information.

D. Record Documents: Update the circuit/raceway block diagrams to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE

A. Schedule a pre-installation conference in accordance with Section 16050, Common Work Results for Electrical, in order to clearly define the requirements specified for equipment identification:

1. Representatives of the Contractor, Owner, and Engineer shall convene before any major purchases of cable or conductors and before the installation or termination of any cables or conductors.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050, Common Work Results for Electrical.

1.08 WARRANTY

A. Refer to Section 16050, Common Work Results for Electrical.

1.09 SYSTEM STARTUP

A. Refer to Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and Signs:

1. One of the following:
   a. Brady.
   b. Seton.
   c. “Or-equal.”

B. Conductor and Cable Markers:

1. Heat-Shrinkable Tubing:
   a. One of the following:
      1) Raychem.
      2) Brady.
      3) Thomas & Betts.
      4) Kroy.
      5) “Or-equal.”
2. Marker Printer:
   a. One of the following:
      1) Brady; XC Plus.
      2) “Or-equal.”

C. Conduit and Raceway Markers:

1. One of the following:
   a. Panduit.
   b. Almetek.
   c. “Or-equal.”

2.02 MATERIALS

A. Nameplates:

1. General:
   a. Identification tags shall utilize the Owner standard numbering system for equipment supplied and installed as part of this Project. Identification tags installed for outdoor equipment shall be rated for weatherproof type.
   b. When identifying a power source for equipment, the tag shall include the source name and circuit or compartment number (i.e., “100MCC0101-4F” or “100IP0101, CKT. #1”).

c. For all equipment, identification shall include the descriptive name on the first line, the CWS standard tag number on the second line and the power source on the third line (e.g., Secondary Clarifier 7 RAS Pump #1 46P1801 Power Source 100MCC0101-4F).
d. Text shall be centered on all nameplates and identification devices.

2. Electrical Equipment:
   a. Disconnect Switches: Each local power disconnect switch and circuit breaker for motors, instrument transmitters, controllers, outlets, and other equipment shall be identified with a phenolic nameplate. The nameplate shall identify the load served by equipment name and tag number, and the power source. Nameplates shall be not less than 1 inch high with lettering not smaller than 1/4 inch. Nameplates shall be attached using self-tapping S.S. screws.
   b. Switchgear and MCC: Each switchgear/MCC shall be identified with a phenolic nameplate (e.g., “100SWGR0101” or “100MCC0101”). Each switchgear/MCC compartment/bucket shall be identified with a phenolic nameplate (e.g., “1A” or “4F”). The nameplate shall identify the load served by name and tag number. Stand-alone starters, drives, and similar equipment shall also identify the power source for the starter, drive, etc. Nameplates shall be attached using stainless steel self-tapping screws. Nameplates shall be not less than 2.25 inches high, with 1-inch high lettering and 1/2-inch high tag number lettering.
   c. Switchgear/MCC Compartments/Buckets, VFDs, Enclosed Starter Panels, and Similar Electrical Equipment: Each compartment/bucket shall be identified with a phenolic nameplate for the load it serves (e.g., “Secondary Clarifier 7 RAS Pump #1, 46P1801”). Stand-alone starters, drives, and similar equipment shall also identify the power source for the starter, drive, etc. Nameplates shall be attached using stainless steel self-tapping screws. Nameplates shall be not less than 2 inches high, with 1/2-inch high lettering and 1/2-inch high tag number lettering.
   d. Local Control Panels (LCP), Local Control Stations (LCS): Each LCP and LCS shall include a nameplate on the enclosure face identifying the panel name and tag number. Include the power source for each panel. Each panel-mounted device (internal and external) shall be identified. Pilot devices shall utilize collar-type, oversize nameplates provided with the pilot devices. Non-pilot devices shall have phenolic nameplates, attached using permanent adhesive. Internal panel devices shall have phenolic identification plates (hand markings not permitted) and shall be attached using permanent adhesive. Wiring and terminal blocks.
      1) LCP and LCS master nameplate shall be not less than 1-inch high with not less than 1/2-inch lettering.

2) External and internal panel devices shall have nameplates not less than 1/2-inch high with not less than 3/16-inch lettering.

e. Field Instrument, Motor, and Pump Identification:
   1) Attach instrument tags to all field instrument devices that includes process switches, instrument elements, sensors, transducers, control valves, motors, and pumps. See Owner's "EQUIPMENT TAG NUMBERING STANDARDS" that includes an example figure and the following list of tagging material:
      a) Tag Material Details:
         (1) Plate Material: Type 316 stainless steel.
         (2) Plate Thickness: 0.30 inches.
         (3) Plate Dimensions: 4-5/8 inches by 2-1/4 inches.
         (4) Round Plate Corners: 1/8 inch radius, all four corners.
         (5) Cable Hole Diameter: 1/4 inch.
         (6) Cable Hole Centerline Location: 1-1/8 from long edge, 1/4 inch from 2-1/4 inch edge.
         (7) Plate Edges: Deburred and smooth.
      b) Label Material: Brady 2-inches wide with M7C-2000-595-WT 2 inch by 4 inch printed label.
      c) Attachment: Stainless steel zip tie.
      d) Font Size is 14-point standard except Instrument Number which is 24-point bold. Label text color shall be black unless instrument is used for DEQ purposes, then text shall be red.
      e) Label text will be capitalized and centered. First line of tag will be Instrument Number. Second and if necessary third line will be Instrument Description. Fourth line will be Instrument Type (pH transmitter, flow transmitter, etc.) Fifth line will be I/O address. Last line will be Power Source Location if four-wire device or say "Loop Powered" if two-wired device.
      f) Need more space add label to back side also.
   2) Attach the nametag to the flexible conduit connection to the respective instrument, motor, or pump.

f. Instrument Panel Instrumentation:
   1) All back of panel instruments shall be provided with black background with white letters plastic laminate nameplates engraved with the instrument's full tag number. Nameplates shall be secured to the panel with stainless steel screws.

2) All front of panel instruments shall include the instrument's full tag number, service description, and (if relevant) power source in the nameplate legend. Unless it is part of the instrument, the nameplate shall be engraved black background with white letters plastic laminate, secured with stainless steel screws.

3. Signs:
   a. Automatic Equipment and High Voltage Signs:
      1) Suitable for exterior use.
      2) In accordance with OSHA regulations.
4. Conductor and Cable Markers:
   a. Machine printed black characters on white tubing.
   b. 10-point type or larger.
5. Conduit and Raceway Markers:
   a. 16 gauge stainless steel, 3/4-inch by 2-inch minimum.
   b. Stamped or engraved lettering.
   c. Minimum 1/4-inch high letters.
6. Equipment and Device Labels:
   a. Provide identifying nameplate and nametag on new and reused panels and equipment as shown in Supplement Signage for Existing Panels and Equipment, or as listed elsewhere. Enclosure identification shall be located on the enclosure surface of PLC control panel, local control stations, junction boxes, and any other power, control, or signal enclosure.
      1) Nameplates: Enclosure identification located on the enclosure face with rectangular screw-on nameplates.
      2) Materials: Laminated phenolic plastic nameplates with black background and engraved white enamel filled lettering.
      3) Fastening: Secure with self-tapping Type 316 stainless steel screws.
      4) Size: 2-1/4-inch high plate.
      5) Test:
         a) Descriptive Name: 1-inch high block lettering.
         b) Descriptive Tag: 1/2-inch high block lettering.
      6) For the same piece of equipment, descriptive nameplate shall be consistently provided at various locations for all associated equipment with that piece.

2.03 SOURCE QUALITY CONTROL

A. Nameplates:

1. Provide all nameplates for control panel operator devices (i.e., pushbuttons, selector switches, pilot lights, etc.):
   a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.
   b. Provide a nameplate on both the front and the back of all pilot device. The nameplate on the back of the device shall be visible when the respective enclosure door on which the pilot device is installed on is OPEN.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050, Common Work Results for Electrical.

B. Nameplates:

1. Attach nameplates to equipment with self-tapping stainless-steel screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment as specified for each equipment.
2. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length: Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

C. Conductor and Cable Markers:

1. Apply all conductor and cable markers before termination.
2. Non-Heat-Shrinkable Tubing:
   a. Tubing shall be sized for the wire and insulation on which it is to be placed.
   b. Tubing shall be tight on the wire.
   c. Characters shall face the open panel and shall read from left to right or top to bottom.
   d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
   e. Identification labels shall be installed at each conductor termination.
   f. Label each spare wire as to where the other end is.

3. Conductor numbers shall be named based on the equipment tag of the field device utilizing the electrical power source. The form of the tag shall be 406P1205C2 where '406P1205' represents the equipment designation; 'C' indicated a control cable and '2' is a sequential number developed as part of the circuit design. Cable type designations shall follow the designations listed below:
   a. C: Control.
   b. S: Signal (below 80 volts ac or dc).
   c. P: Power.
   d. N: Network (Ethernet, Profibus).

D. Conduit Markers:

1. Furnish and install conduit markers for every conduit in the electrical system or part of the process system. Conduits shall be identified as indicated on the circuit/raceway block diagrams.
   a. Conduit markings shall match the circuit/raceway block diagrams.
   b. For conduits not shown on circuit/raceway block diagrams, provide conduit markings as described below:
      1) Start with a prefix letter that designates its purpose ("C" for control, "P" for power, "S" for Signal, and "PC" for combined power and control), followed by a facility code, followed by a sequence number. e.g., C-100P0101 is a control conduit in the IPS facility for Pump 1. P-100P0101 is a power conduit in the IPS facility for Pump 1. S-100P0101 is a signal conduit in the IPS facility for Pump 1. PC-340FV1301 is a combined power and control conduit in IPS facility for control valve (Combined circuit allowed per Owner approval only).
      2) If the conduit is a continuation or branch of another conduit, the last space is a letter, such as A, B, C, etc.
      3) When a single loop network circuit is utilized among equipment, conduit number for coming and leaving the equipment shall be assigned a prefix from and to. e.g., NFR: 100P0101 is a communication network from IPS Facility Pump 1. NTO: 100P0102 is a communication network to IPS Facility Pump 2.
2. Mark Conduits at the following Locations:
   a. On each end and every 100 feet for conduits greater than 10 feet in length.
   b. Where the conduit penetrates a wall or structure.
   c. Where the conduit emerges from the ground, slab, etc.
3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.

5. 16-gauge Stainless Steel Tags 3/4-inch by 2-inch Minimum: Conduit tags shall be attached to the raceway with Type 316 stainless steel wires. Tags shall be laser engraved.
6. Mark conduits before construction review by Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the National Electrical Code (NEC).

E. Labeling:

1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
   a. Fasten warning signs with round head stainless steel screws or bolts.
   b. Locate and mount in a manner to be clearly legible to Operations Personnel.
2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, and where the voltage exceeds 600 volts.
3. Place warning signs on utilization equipment that has more than one source of power. Use warning signs to identify every panel and circuit number of the disconnecting means all external power sources:
   a. Place warning signs on utilization equipment that has 120V ac control voltage sources used for interlocking.
   b. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
4. Each switch, receptacle and similar device shall include a nameplate indicating the power source and circuit number providing power to the switch or receptacle. For circuits other than 120V, identify the voltage and phase (e.g., 277V, 1Ø or 480V, 3Ø).
5. Each panelboard shall be identified with a phenolic nameplate with the black outside cut to expose white lettering. The nameplate shall include the panel name and tag number, voltage, phase, ampere rating and power source. Nameplate shall be 2.25 inches high with 1/2-inch high lettering and attached using self-tapping stainless-steel screws.
6. Each manhole, handhole, vault or underground pull box lid shall be clearly identified as “Electric.” The text shall be stick welded onto the lid with 4-inch uppercase characters. The text shall include the identification number shown on the Drawings, and shall further identify the manhole, handhole or pull box as “Medium Voltage Power,” “Low Voltage Power,” “Control,” “Signal” or “Communication,” as applicable.
7. Aboveground pull boxes, junction boxes and terminal boxes shall be identified using a stainless-steel tag attached to the enclosure using stainless steel self-tapping screws. Identify the box as “Power,”

"Control," "Signal" or "Fiber Optic" as applicable. Assign unique box numbers in accordance with Owner standards.

8. Provide arc flash labeling in accordance with NEC.
9. Provide labeling indicating short circuit ratings for all power distribution equipment and control panels in accordance with the NEC and UL requirements. Label outside of all boxes with phenolic label. Nameplates shall be no less than 2.25 inches high with 1-inch high lettering and 1/2-inch high tag number lettering. Example: Electrical Junction Box, Electrical Pull Box, Control Junction Box, Control Pull Box, etc.
    a. Inside all pull junction boxes place Brady label by each conduit identifying what is fed.

F. Signs:

1. Automatic Equipment and High Voltage Signs:
    a. Mount permanent warning signs at mechanical equipment that may be started automatically from remote locations. Fasten warning signs with round head stainless steel screws or bolts. Locate and mount warning signs in a suitable manner that is acceptable to the Engineer.
    b. Mount permanent and conspicuous warning signs on the front and back of equipment, doorways to equipment rooms, pull boxes, and manholes where the voltage exceeds 600 volts.
    c. Place warning signs on equipment that has more than one source of power: Warning sign to identify every power source.
    d. Place warning signs on equipment that has a 120V ac control voltage source used for interlocking.
2. Provide room signage at Electrical room entrances indicating "Warning-High-Voltage."
3. Provide additional signage in accordance with applicable NEC requirements.
4. Provide 20 placard-style signs (7 inches by 10 inches) with warnings to be selected by the Owner during construction. Placard signs shall be W.H. Brady; B-302 style, "or-equal."

G. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.02 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.03 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Tagging Submittal.

END OF SECTION

Knife Disconnects

EQUIPMENT TAG	TAG TYPE	TAG SIZE	LOCATION	TEXT ON LABEL

Electrical Equipment Tag

EQUIPMENT TAG	TAG TYPE	LOCATION	TEXT ON TAG

Instrument Equipment Tag

EQUIPMENT TAG	TAG TYPE	LOCATION	TEXT ON TAG

Toggle Disconnects

EQUIPMENT TAG	TAG TYPE	TAG SIZE	LOCATION	TEXT ON LABEL

Conduit

CONDUIT TYPE	EQUIPMENT	SIZE	TEXT ON TAG	Quantity

SECTION 16123
600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. 600-volt class wire and cable.
2. Instrumentation class wire and cable.
3. Network cable, including fiber optic cable.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Refer to Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. B3, Standard Specification for Soft or Annealed Copper Wire.
   b. B8, Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   c. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
3. Building Industry Consulting Service International (BICSI).
4. Federal Specification J-C 30A.
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations.
6. Insulated Cable Engineers Association (ICEA):
   a. IPCEA S-61-402 for thermoplastic insulated wire and cable for the transmission and distribution of electrical energy.
   b. IPCEA S-61-402 for rubber insulated wire and cable for the transmission and distribution of electrical energy.

c. T-29-520, Conducting Vertical Cable Tray Flame Tests and a Theoretical Heat Input of 210,000 Btu/hour.
d. S-58-679, Standard for Control Cable Conductor Identification.

7. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 55, Instrumentation Cables and Thermocouple Wire.
   c. WC 70, Standard for Nonshielded Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
8. National Fire Protection Association (NFPA):
   a. Article 70, National Electrical Code (NEC).
   b. Article 72, National Fire Alarm Code.
   c. Article 101, Life Safety Code.
   d. Article 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
9. UL:
   a. 13, Standard for Safety Power-Limited Circuit Cables.
   b. 44, Standard for Safety Thermoset - Insulated Wires and Cables.
   c. 62, Standard for Safety Flexible Cord and Fixture Wire.
   d. 486A, Standard for Safety; Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   e. 486C, Splicing Wire Connectors.
   f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety Service-Entrance Cables.
   h. 1063, Machine-Tool Wires and Cables.
   i. 1277, Electrical Power and Control Tray Cables with Optional Optical-fiber Members.
   j. 1424, Cables for Power-Limited Fire-Alarm Circuits.
   k. 1569, Metal-Clad Cables.
   l. 1581, Reference Standard for Electrical Wires, Cables, and Flexible Cords.
   m. 2196, Tests for Fire Resistive Cables.
   n. 2225, Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. Refer to Section 16050, Common Work Results for Electrical.

B. Definitions of terms and other electrical considerations as set forth in the:

1. ASTM International (ASTM).
2. Insulated Cable Engineering Association (ICEA).

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer of wire and cable.
2. Insulation:
   a. Type.
   b. Voltage class.
3. American Wire Gauge size.
4. Conductor material.
5. Pulling compounds.

C. Shop Drawings:

1. Show Splice Locations: For each proposed splice location, provide written justification describing why the splice is necessary. Splices are not allowed unless approved by the Owner.

D. Test Reports:

1. Submit test reports for megohm 1,000V dc tests.
2. Submit test reports for continuity tests.
3. Submit test reports for fiber optic cable testing.
4. All test shall conform with NETA standards. An electronic PDF copy of the test reports shall be provided to the Owner.

E. Calculations:

1. Submit cable pulling calculations for all cables larger than 2/0 AWG and pulling lengths longer than 200 feet.
2. Submit cable pulling calculations for all conductor sizes for pulling lengths longer than 500 feet.
3. Submit the calculations to the Engineer a minimum of 2 weeks before the cable pull.

1.06 CABLE TESTING AND REPLACEMENT

A. All cables that fail to meet NETA standards shall be replaced at the discretion of the Engineer and Owner.

B. All wires and cables shall be tested individually.

C. All tests shall conform to NETA standards.

1.07 QUALITY ASSURANCE

A. Refer to Section 16050, Common Work Results for Electrical.

B. All wires and cables shall be UL listed and labeled. CSA and TUV are acceptable.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. Refer to Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. Refer to Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. 600-Volt Class Wire and Cable:
   a. General Cable.
   b. Okonite Company.
   c. Southwire Company.
   d. “Or-equal.”
2. Instrumentation Class Wire and Cable:
   a. Alpha Wire Company.
   b. Belden CDT.
   c. General Cable BICC Brand.
   d. Okonite Company.
   e. Rockbestos Surprenant Cable Corporation.
   f. “Or-equal.”

3. Network Cables:
   a. Belden CDT.
   b. Siemens.
   c. Lucent.
   d. “Or-equal.”
4. Fiber Optic Cables:
   a. AFL.
   b. Corning.
   c. “Or-equal.”

2.02 MATERIALS

A. Conductors:

1. Copper per ASTM B3.
2. Minimum 97 percent conductivity.

2.03 MANUFACTURED UNITS

A. General:

1. Conductors, include grounding conductors, shall be stranded copper. Solid conductors shall not be permitted. Aluminum conductor wire and cable will not be permitted.
2. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
3. Permanently mark each wire and cable with the following at 24-inch intervals:
   a. American Wire Gauge (AWG) size.
   b. Voltage rating.
   c. Insulation type.
   d. UL symbol.
   e. Month and year of manufacture.
   f. Manufacturer’s name.
4. Identify and mark wire and cable as specified in Section 16075, Electrical Identification:
   a. Use integral color insulation or colored heat shrink for 2 AWG and smaller wire.
   b. Wrap colored tape around cable larger than 2 AWG. Tape shall be 2 inches minimum. Provide three wraps minimum.

B. 600-Volt Class Wire and Cable:

1. Provide American Wire Gauge (AWG) or kcmil sizes as indicated on the Drawings:
    a. When not indicated on the Drawings, size wire as follows:
        1) In accordance with the National Electrical Code:
            a) Use 75 degrees C ampacity ratings.
            b) Ampacity rating after all derating factors, equal to or greater then rating of the overcurrent device.
        2) Provide 12 AWG minimum for power conductors.
        3) Provide 14 AWG minimum for control conductors.
    b. Provide tin plated copper ground wire to be used on aluminum cable tray.
2. Provide Class B Stranding per ASTM B8: Provide Class C stranding where extra flexibility is required.
3. Insulation:
    a. XHHW-2 for all individual power conductors 6 AWG and larger.
    b. THWN for all individual power conductors small than 6 AWG.
    c. THWN for all individual control conductors.
    d. 90 degrees C rating in wet or dry locations.
4. Conductors for feeders shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to farthest connected load does not exceed 5 percent.
5. Flexible Cords and Cables:
    a. Type SOOW with ethylene propylene rubber insulation in accordance with UL 62.
    b. Conform to physical and minimum thickness requirements of NEMA WC 70.
    c. Used with three-phase receptacles and inlets.
6. Multiconductor Cables:
    a. Type 1, Multiconductor Control Cable:
        1) Conductors:
            a) 14 AWG, seven-strand copper, tray cable rated.
            b) Insulation: 30-mil PVC.
            c) UL 1581 listed as Type THHN/TWWN-2 rated VW-1.
            d) Conductor group bound with spiral wrap of barrier type.
            e) Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
            f) Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.

2) Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.50	45
6	0.53	45
9	0.64	60
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

b. Type 2, Multi-conductor Power Cable:

1) Conductors:
   a) Class B stranded, coated copper.
   b) Insulation: Chemically cross-linked ethylene-propylene.
   c) UL 1581 listed as Type EPR, rated VW-1.
   d) Color Code:
      (1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      (2) Conductors, size 6 AWG and larger, ICEA S-58-679, Method Y.
2) Cable pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3) Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
8	10	2	0.62	60
		3	0.66	60
		4	0.72	60
6	8	3	0.74	60
		4	0.81	60
4	6	3	0.88	60
		4	0.97	80
2	6	3	1.01	80
		4	1.11	80
1/0	6	3	1.22	80
		4	1.35	80
2/0	4	3	1.32	80
		4	1.46	80
4/0	4	3	1.56	80
		4	1.78	110

7. Instrumentation Cables:
   a. Type 3, 18 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log application is meeting NEMA WC 55 requirements.
      1) Outer Jacket: 45-mil nominal thickness.
      2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
      3) Dimension: 0.31-inch nominal OD.
      4) Conductors:
         a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
         b) 20 AWG, seven-strand tinned copper drain wire.
         c) Insulation: 15-mil nominal PVC.
         d) Jacket: 4-mil nominal nylon.
         e) Color Code: Pair conductors black and white.

b. Type 4, 18 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, design for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1) Outer Jacket: 45-min nominal.
   2) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
   3) Dimension: 0.32-inch nominal OD.
   4) Conductors:
      a) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      b) 20 AWG, seven-strand, tinned copper drain wire.
      c) Insulation: 15-mil nominal PVC.
      d) Jacket: 4-mil nylon.
      e) Color Code: Triad conductors black, red, and white.

c. Type 5, 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.
   1) Conductors:
      a) Bare soft annealed copper, Class B, seven-strand concentric, in Accordance with ASTM B8.
      b) Tinned copper drain wires.
      c) Pair drain wire size AWG 20, group drain wire size AWG 18.
      d) Insulation: 15-mil PVC.
      e) Jacket: 4-mil nylon.
      f) Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
      g) Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
   2) Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3) Cable Sizes:

Number of Pairs	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

d. Instrument cord and plug:
   1) Two Pole:
      a) Brad Connectivity 2P, female straight 6 feet, 16/2 AWG PVC cord.
         (1) Product Number: 1300060091.
         (2) No exceptions.
      b) Brad Connectivity 2P, male straight 12 inches, 16 AWG PVC leads.
         (1) Product Number: 1300130076.
         (2) No exceptions.
   2) Three Pins:
      a) Power Cord and Plug: Brad Connectivity 3P, female straight 6 feet, 16/3 AWG PVC cord.
         (1) Product number: 1300060221.
         (2) No exceptions.
      b) Brad Connectivity 3P, male straight 12 inches, 16 AWG PVC leads.
         (1) Product number: 1300130202.
         (2) No exceptions.
   3) Analog Cord and Plug:
      a) Brad connectivity 2P, female straight 6 feet, 16/2 AWG PVC cord.
         (1) Product number: 1300060091.
         (2) No exceptions.
      b) Brad connectivity 2P, male straight 12 inches, 16 AWG PVC leads.
         (1) Product number: 1300130076.
         (2) No exception.

8. VFD Cables:
   a. Type 6, Flexible, shielded triad VFD cable with three symmetrical ground conductors:
      1) UL 2277, 1,000V flexible motor supply cable.
      2) TC-ER rated, 90 degrees C wet or dry.
      3) Conductors:
         a) 12 AWG thru 10 AWG, tinned copper per ASTM B33, Class K stranding per ASTM B172.
         b) 8 AWG through 2 AWG, tinned copper per ASTM B33, Class H stranding per ASTM B173.
         c) Insulation: 45-mil XLPE for conductors 12 AWG through 10 AWG; 60-mil XLPE for conductors 8 AWG through 2 AWG.
         d) Three full-sized green solid or yellow-striped insulated ground conductors, same AWG size as the circuit conductors.
      4) Cable Shield: Overall aluminum shield with minimum 25 percent overlap with overall tinned copper braid with 85 percent coverage and full sized tinned copper drain wire(s).
      5) Jacket: UV-sunlight resistant, flame retardant and chemical resistant, per UL 1277.
      6) Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors (not including ground)	Max Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	3	0.70	60
10	10	3	0.74	60
8	8	3	0.94	80
6	6	3	1.03	80
4	4	3	1.17	80
2	2	3	1.33	80

9. DLO Cables:
   a. Type 8, Diesel Locomotive Cable:
      1) Conductors:
         a) 2,000-volt, stranded copper.
         b) Insulation: Ethylene propylene rubber.
         c) Jacket: Chlorinated polyethylene.

d) UL 44, 1685 Listed for types RHH, RHW-2, and VW-1.
e) Suitable for continuous use.

2) Cable: Passes the FT-4/IEEE1202 for #2/0 through 1,111 kcmil. Passes the UL 1685 ST-1 smoke release test for #2/0 through 1,111 kcmil.
3) DLO cables shall only be permitted to be used within a control panel. DLO cables shall not be permitted to be used for any other application.

10. Armored Cables:
a. Type 9, HFC-Type Cables:
1) Cables:
a) Stranded copper, 19 strands minimum.
b) Insulation: THHN.
c) Integral grounding conductor, fully sized.
d) Integral 16 AWG bonding wire.
e) Interlocking aluminum armor with green stripe. The armor and bonding wire shall serve as a redundant ground.
f) Use only duplex, screw-clamp fittings, approved for use with AFC-type cable.
g) Healthcare Facilities Type (HCF).
2) Supports:
a) Support every 12 inches from a junction box or enclosure.
b) Support every 54 inches maximum.

C. Network Cables:

1. Type 11, Shielded Category 6 (CAT 6):
a. Conductors:
1) 23 AWG solid bare copper conductors, 26 AWG drain wire.
2) Shielded cable with shielded connectors.
3) Overall Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
4) Provide red stain relief boots over connectors.
b. Insulation:
1) Polyolefin.
2) Four non-bonded twisted pair cables formed into a cable core.
c. Color Code:
1) Pair 1: White/Blue Stripe and Blue.
2) Pair 2: White/Orange Stripe and Orange.
3) Pair 3: White/Green Stripe and Green.
4) Pair 4: White/Brown Stripe and Brown.

d. Outer Jacket:
   1) PVC with ripcord.
   2) Color red.
   3) CMR rated.
e. Electrical Characteristics:
   1) Frequency Range: 0.772 MHz to 100 MHz.
   2) Attenuation: 32.1 dB/100m.
   3) Near-End Crosstalk (NEXT): 39.3 dB.
   4) Power Sum NEXT: 37.3 dB.
   5) Attenuation to Crosstalk Ratio: 7.2 dB.
   6) Power Sum Attenuation to Crosstalk Ratio: 5.3 dB/100m.
   7) Equal Level Far-End Crosstalk (ELFEXT): 22.8 dB.
   8) Power-Sum ELFEXT: 19.8 dB/100m.
   9) Return Loss: 17.3 dB.
   10) Propagation Delay: 537 ns/100m.
   11) Delay Skew: 45 ns/100m.
   12) Propagation Delay (Skew), Maximum: 2.5 ns/100m.
f. Manufacturer and Product:
   1) Commscope; UN8840015104/10.
   2) “Or-equal.”
g. RJ45 Jacks:
   1) Shall be CAT6 shielded.
   2) Punch down and terminate on jacks as shown on the Drawings.
h. Patch Panels:
   1) Shall be CAT6 shielded patch panels.
   2) Punch down and terminate on patch panels as shown on the Drawings.
i. Terminate CAT6 cables in an 8P8C T568B fashion.

2. Fiber Optic Cables:
   a. Type: Single mode, Optic Fiber Non-conductive Riser (OFNR), tight buffered.
   b. Rating:
      1) Tight Buffered Indoor/Outdoor.
      2) Plenum Rated OFNR.
   c. Fiber Count: As shown on the Drawings.
   d. Preferred Jacket Color: Black.
   e. Connectors: Do not use pre-terminated connectors. Terminate at LC type connectors after installation.
      1) Connector Type: LC UPC Splice-ON connectors.
   f. Splicing: Not allowed, fiber shall be continuous from point of origin to termination. Cutting and splicing in the field is not acceptable.

g. Manufacturer and Product:
   1) Corning FREEDM OS2.
   2) “Or-equal.”

2.04 ACCESSORIES

A. Tape:

1. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.

B. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.

C. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 600 volts of same material as conductor metal.
3. Insulated, Locking-Fork, Compression Lugs:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) ILSCO; ILSCONS.
4. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Long-barrel compression.
   c. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy, Hydent.
      3) ILSCO.

D. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.
3. Cable ties installed outdoors shall be UV resistant and rated for use in direct sunlight. Finish shall be black.

E. Heat Shrinkable Insulation:

1. Thermally stabilized, cross-linked polyolefin.
2. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

F. Pulling Compound:

1. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
2. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
3. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
4. Manufacturers:
   a. Polywater, Inc.
   b. Ideal Clear Glide.

G. Innerduct:

1. Provide innerduct for fiber optic cable installations.
2. Function: Installs into conduit system to provide smooth, low-friction path through conduit.
3. Size: 25 mm or 32 mm innerduct installed in 2-inch conduit.
4. Type: Annular corrugated innerduct.
5. Color: Orange with pull string pre-installed.
6. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
7. Lubrication: Pre-lubricated.
8. Manufacturers:
   a. Endocor.
   b. Dura-Line.

2.05 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirement of ICEA Publication No. S-68-516.

B. Test in accordance with the requirements of UL 44 and UL 854 Standards.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 16050, Common Work Results for Electrical.

B. Color Coding:

1. Color coding shall be consistent throughout the facility.
2. The following color code shall be followed for all 240/120 Volt and 208/120 Volt systems:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Single Phase System: Black for one hot leg, red for the other.
   e. Neutral: White.
   f. High Phase or Wild Leg: Orange.
   g. Equipment Ground: Green.
3. The following color code shall be followed for all 480/277 Volt systems:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: Gray.
   e. Equipment Ground: Green.
4. The following color code shall be followed for all 120V ac control wiring:
   a. Power: Red.
   b. Neutral: White.
5. The following color code shall be followed for all general purpose DC control circuits:
   a. Negative: White/blue stripe.
   b. Positive: Blue.
6. The following color code shall be followed for all signal (4 mA to 20 mA or 1V dc to 5V dc) circuits:
   a. Negative: Black.
   b. Positive: White.
7. Switch legs shall be violet. Three-way switch runners shall be pink.
8. Wires in intrinsically safe circuits shall be light blue.
9. Wire colors shall be implemented in the following methods:
   a. Wires manufactured of the desired color.
   b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape: Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:

1. Install wires only in approved raceways.
2. Do not install wire:
   a. In incomplete conduit runs.
   b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits and prevent mechanical damage to conductors during installation:

1. For all 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit.

E. Cable Pulling:

1. For cables 1 AWG and smaller, install cables by hand.
2. For cables larger than 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
3. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer and Owner may, at his discretion, require replacement of the cable.
4. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
5. Make splices or add a junction box or pull box where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
   a. Make splices in manholes or pull boxes only.
   b. Leave sufficient slack to make proper connections.
   c. Splices in manholes shall consist of crimp connections with heat shrinkable tubing.
   d. Splices in pull boxes shall utilize insulated terminal blocks.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

G. Install and terminate all wire in accordance with manufacturer’s recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:

1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool: Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

I. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head: Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.

J. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug: Use ring type lugs if box lugs are not available on the equipment.

K. Splices:

1. Provide continuous circuits from origin to termination whenever possible. Obtain Owner's written approval prior to making any splices.
2. Lighting and receptacle branch circuits may be spliced without approval from the Owner.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
    a. Refer to Section 16050, Common Work Results for Electrical, for box NEMA rating requirements.
    b. Make splices in labeled junction boxes for power conductors.
    c. Make splices for control and instrument conductors in terminal boxes or FD boxes near the instrument:
        1) Provide terminal blocks.
        2) Terminate all conductors on terminal blocks with wire ferrules.
        3) Splices shall not be made in conduit bodies.
4. Splices not permitted for power and control conductors.
5. If splices have been approved by the Owner, clearly label junction and terminal boxes containing splices with the word "SPLICE." Provide this label on approved power, control, and signal junction and terminal boxes.
6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve: In NEMA 4 or NEMA 4X areas, provide heat-shrink sleeves that are listed for submersible applications.

8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
   a. A heat shrink insulating system listed for submersible applications.
   b. An epoxy resin splicing kit.
   c. Other approved direct burial splice kit.

L. Apply circuit and wire markers to all wires and cables as described below:

1. Circuit Identification Location: Identify power, instrumentation, and control conductor circuits, using circuit name as described below, at each termination and in accessible locations such as manholes, hand-holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
2. Circuit Name:
   a. Assign circuit name based on device or equipment at load end of circuit as indicated on the Drawings and as described in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   b. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
3. Method:
   a. Conductors 500 AWG and Smaller: Identify with sleeves or heat bond markers.
   b. Taped-on markers or tags relying on adhesives not permitted.
   c. Cables and Conductors No. 600 and Larger:
      1) Identify with marker plates; or
      2) Tie-on cable marker tags.
      3) Attach with nylon tie cord.

M. Instrumentation Class Cable:

1. Install instrumentation class cables in separate raceway systems from power cables:
   a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
   b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
3. Refer to Section 16050, Common Work Results for Electrical, for shield grounding requirements.

N. Signal Cable: Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches. Perpendicular crossings shall be acceptable.

O. Unsupported Cables: Provide Kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

P. Wiring Allowances:

1. Equipment locations may vary slightly from the Drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the Drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations as indicated on the Drawings.

Q. Wiring within Cabinets and Enclosures: All wiring within a cabinet or enclosure shall be insulated.

R. Wire Ferrules: All conductors 14 AWG and smaller that terminate on terminal blocks shall be terminated using wire ferrules.

S. Fiber Optic Cables:

1. Installation of Fiber Optic Cables:
   a. Performed in accordance with BICSI standards and work done by installer with BICSI Installer 2, Optical Fiber (INSTF) certification.
   b. Install in innerduct.
   c. Installed in accordance with manufacturer's requirements.
2. During installation, ensure that cable is:
   a. Not dented, nicked, or kinked.
   b. Not subjected to pull stress greater than manufacturer's specification.
   c. Not bent to a radius below manufacturer's minimum bend radius.
   d. Not subjected to treatment that may damage fiber strands during installation.
   e. Installed complete between termination points, with no intermediate splices.
   f. Arranged neatly at termination enclosures with 10-foot slack service loop.

3. Terminations:
   a. In accordance with TIA 568 C.3.
   b. Connectors: Terminate 100 percent of the fibers in each cable with LC connectors at existing fiber optic patch panels.
   c. Provide two OM3 fiber patch cords, two fibers per cord with LC style connectors, 10-feet long.

3.02 CATEGORY CABLE TESTING

A. The permanent link shall be tested.

B. All test results shall be used by the Contractor to determine any polarity and noise anomalies and Contractor shall take immediate corrective action for all anomalies.

C. Test results shall be used by the Contractor to determine the viability of each sheath for transmission in accordance with the specifications of the cable manufacturer and the requirements imposed by the transmission system. This shall form part of the acceptance procedure for the cable plant. All results obtained by use of pair-scanner testing shall be collated by terminal outlet number and or riser pair number and presented to the Owner at the conclusion of the testing. Test compilation shall be initialed and dated by the Contractor's technician performing the test.

D. The Contractor shall utilize a Level-III Fluke, PentaScanner, Wavetek, "or-equal," twisted pair test instrument for the testing of all System Category copper cabling. All Category cable paths shall be tested at each jack for the following parameters and meet the requirements imposed by the TIA/EIA 568-B3 building wiring standard.

E. Category data cabling systems shall be performance verified using an automated test set. This test set shall be capable of testing for the continuity and length parameters defined above and provide for the following tests:

1. Wire Map.
2. Cable Length.
3. Pair-to-Pair NEXT.
4. Power Sum NEXT.
5. Attenuation.
6. Pair-to-Pair ELFEXT.
7. Power Sum ELFEXT.
8. Return Loss.
9. Propagation Delay.
10. Delay Skew.

F. A complete cable certification report shall be provided covering all locations.

G. The Contractor shall compile test results into the forms that contain all applicable test data. An external drive containing the test data and appropriate application (software) to display such in a windows-based environment shall be provided.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 16050, Common Work Results for Electrical.

B. Grounding: Refer to Section 16060, Grounding and Bonding.

C. Fiber Optic Cable Testing:

1. As part of this Contract, provide the services of an independent third-party tester to verify and test all optical fibers and LC connectors installed under this contract. The third-party tester shall have a minimum of 5 years of verifiable work experience performing fiber testing. A written list of references shall be made available to the Owner, if requested.
2. Test all fibers and connectors using an OTDR and provide traces with maximum fiber loss in compliance with standard TIA-568-C, not exceeding:
   a. 3 dB/km at 850 nm wavelength.
   b. 1.2 dB/km at 1300 nm wavelength.
   c. 0.4 dB per connector.
3. All fiber that fails the testing shall be replaced by the Contractor at no additional cost to the Owner.
4. Submit all test results to the Owner in electronic PDF.

3.04 PROTECTION

A. Refer to Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16130
CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metallic conduits.
2. Nonmetallic conduits.
3. Conduit bodies.
4. Conduit fittings and accessories.
5. Conduit installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American National Standards Institute (ANSI):
   a. C80.1, Electrical Rigid Steel Conduit.
   b. C80.3, Steel Electrical Metallic Tubing.
   c. C80.5, Electrical Rigid Aluminum Conduit.
   d. C80.6, Electrical Intermediate Metal Conduit.
3. National Electrical Manufacturer's Association (NEMA):
   a. RN-1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   b. TC2, Electrical Polyvinyl Chloride (PVC) Conduit.
   c. TC3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   d. TC7, Smooth-Wall Coilable Electrical Polyethylene Conduit.
   e. TC13, Electrical Nonmetallic Tubing.
   f. TC14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

4. UL:
    a. 1, Standard for Flexible Metal Conduit.
    b. 6, Standard for Electrical Rigid Metal Conduit - Steel.
    c. 6A, Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
    d. 360, Standard for Liquid-Tight Flexible Steel Conduit.
    e. 651, Standard for Schedule 40 and Schedule 80 Rigid PVC Conduit and Fittings.
    f. 651B, Standard for Continuous Length HDPE Conduit.
    g. 797, Standard for Electrical Metallic Tubing - Steel.
    h. 1242, Standard for Electrical Intermediate Metal Conduit - Steel.
    i. 1653, Standard for Electrical Nonmetallic Tubing.
    j. 1660, Standard for Liquid-Tight Flexible Nonmetallic Conduit.
    k. 1684, Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions and Abbreviations:

1. Conduit Bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of two or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.
2. Conduit Fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
3. EFLX: Explosionproof flexible conduit.
4. FLX: Flexible steel conduit.
5. EMT: Electrical Metallic Tubing conduit.
6. GRC: Galvanized rigid steel conduit.
7. NPT: National pipe thread.
8. PCS: PVC coated rigid steel conduit.
9. PVC: Polyvinyl chloride rigid nonmetallic conduit.
10. RAC: Rigid aluminum conduit.
11. SLT: Sealtight – liquid-tight flexible steel conduit.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.
4. List of manufacturer's recommended spare parts.

C. Certifications: Furnish PVC-coated conduit manufacturer's certification for each installer.

D. Record Documents:

1. Incorporate all changes in conduit routing on electrical plan drawings.
2. Dimension concealed conduits from building lines.
3. Furnish hard copy drawings and electronic files in AutoCAD format Version 2010.

E. Installation Drawings: Installation drawings, including individual conduit numbers, routing, sizes, cable sizes, and circuit numbers for each conduit.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.

C. Every installer of PCA or PCS conduits shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Do not expose type PVC, FRD, NFC and ENT to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:

1. Examine the complete set of Drawings and Specifications, and all applicable Shop Drawings.
2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Galvanized Rigid Steel Conduit:

1. One of the following:
   a. Western Tube and Conduit.
   b. Allied Tube and Conduit.
   c. Wheatland Tube Co.
   d. “Or-equal.”

B. Polyvinyl Chloride-coated Rigid Steel Conduit:

1. One of the following:
   a. Robroy Industries.
   b. Ocal, Inc.
   c. “Or-equal.”

C. Rigid Aluminum Conduit (RAC).

1. One of the following:
   a. Allied Tube and Conduit.
   b. Patriot Aluminum Products.
   c. Republic Conduit.

d. Wheatland Tube Co.
e. “Or-equal.”

D. Flexible Steel Conduit:

1. One of the following:
a. AFC Cable Systems.
b. Southwire.
c. Electri-flex Company.
d. “Or-equal.”

E. Sealtight Liquid-tight Flexible Steel Conduit:

1. One of the following:
a. Thomas & Betts; LTA (gray).
b. Southwire; Titan (gray).
c. Anaconda Sealtite; UVUA (black).

F. Explosionproof Flexible Conduit:

1. One of the following:
a. Appleton.
b. Crouse Hinds.
c. Hubbell Killark.
d. “Or-equal.”

G. Electrical Metallic Tubing:

1. One of the following:
a. Allied Tube and Conduit.
b. Patriot Aluminum Products.
c. Republic Conduit.
d. Wheatland Tube Co.
e. “Or-equal.”

H. Conduit Bodies:

1. One of the following:
a. Crouse-Hinds.
b. Appleton.
c. O-Z/Gedney.
d. Ocal.
e. Robroy.
f. Carlon.
g. “Or-equal.”

I. Galvanized Rigid Steel Conduit Expansion Fittings:

1. One of the following:
   a. Crouse-Hinds.
   b. Appleton.
   c. O-Z/Gedney.
   d. “Or-equal.”

J. Conduit Sleeve:

1. One of the following:
   a. Crouse-Hinds.
   b. Appleton.
   c. O-Z/Gedney.
   d. “Or-equal.”

K. Conduit Seals:

1. One of the following:
   a. Appleton.
   b. Crouse-Hinds.
   c. O-Z/Gedney.
   d. “Or-equal.”

L. Conduit Hangers and Supports: As specified in Section 16070, Hangers and Supports.

M. Conduit through Wall and Floor Seals:

1. The following:
   a. O-Z/Gedney:
      1) Type “WSK”.
      2) Type “CSM”.
   b. “Or-equal.”

2.02 COMPONENTS

A. GRC:

1. All Threads:
   a. NPT standard conduit threads with a 3/4-inch taper per foot:
      1) Running conduit threads are not acceptable.
2. Hot-dip Galvanized Inside and Out: Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface. Electro-galvanizing is not acceptable.

3. Manufactured in accordance with:
   a. UL 6.
   b. ANSI C80.1.

B. PCS:

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
2. Coated Conduit NEMA Standard RN-1: The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory-bonded PVC Jacket:
   a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
   b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece, dictate otherwise.
   c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
   d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
      1) Confirm bond with certified test results.
4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
   a. Nominal thickness of 0.002 inch.
   b. Conduit having areas with thin or no coating, are not acceptable.
   c. All threads shall be coated with urethane.
5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees F.
6. PCS Conduit Bodies and Fittings:
   a. Malleable iron.
   b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
   c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
   d. 0.002-inch interior urethane coating.
   e. Utilize the PVC coating as an integral part of the gasket design.
   f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.

g. A PVC sleeve extending one conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
   1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
   2) The sleeve shall provide a vapor and moisture tight seal at every connection.

C. RAC:

1. Rigid aluminum conduit shall be manufactured of Alloy 6063-T1.
2. Manufactured in accordance with:
   a. ANSI C80.5.
   b. UL 6A.
3. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

D. EMT:

1. Hot galvanized steel with corrosion resistant inner diameter coating.
2. Manufactured in accordance with:
   a. ANSI C80.3.
   b. UL 797.
3. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

E. FLX:

1. Materials: Single strip steel hot-dip galvanized on all four sides before conduit fabrication.
2. Interlocking design formed from continuous metal strip for integrity and flexibility.
3. Manufactured in accordance with UL 1.

4. Use of this conduit type is restricted to only locations permitted in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

F. SLT:

1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
   a. General Purpose: Temperature range minus 20 degrees C to plus 60 degrees C.
   b. Oil Resistant: Temperature range minus 20 degrees C to plus 60 degrees C.
2. Sunlight resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all four sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.

G. EFLX:

1. Suitable for the hazardous Class and Group where installed as specified in Section 16050, Common Work Results for Electrical.
2. Metallic braid shall provide continuous electrical path.
3. Stainless steel construction.
4. Provide fittings and unions as required for the installation.

H. PVC:

1. Extruded from Virgin Polyvinyl Chloride Compound:
   a. Schedule 40 unless otherwise specified.
   b. Schedule 80 extra heavy wall where specified.
2. Rated for 90 degrees C conductors or cable.
3. Rated for use in direct sunlight.

I. Conduit Bodies:

1. Material Consistent with Conduit Type:
   a. Malleable iron bodies and covers when used with Type GRC conduit.
   b. Cast aluminum bodies and covers when used with Type RAC.
   c. PVC bodies and covers when used with Type PVC.
   d. PVC-coated malleable iron bodies and covers when used with Type PCS.

e. PVC-coated copper-free cast aluminum bodies and covers when used with Type PCA.
f. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.

2. Conduit Bodies to Conform to Form 7 or Mogul Design: Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors 4 AWG and larger, or where required for wire bending space.
3. The cover shall have wedge-nut clips with integral gaskets for easy installation and removal. This applies to all material types.

2.03 ACCESSORIES

A. Connectors and Fittings: Manufactured with compatible materials to the corresponding conduit.

B. Insulated Throat Metallic Bushings:

1. Construction:
a. Malleable iron when used with steel conduit.
b. Aluminum when used with aluminum conduit.
c. Positive metallic conduit end stop.
d. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees C.
e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees C rated noncombustible thermosetting phenolic.

C. Insulated Grounding Bushings:

1. Construction:
a. Malleable iron with a positive metallic end stop.
b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees C.
c. Tin plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical Unions (Erickson Couplings):

1. Construction:
a. Malleable iron for use with steel conduit.
b. Aluminum for use with aluminum conduit.
c. Concrete tight, three-piece construction.
d. Rated for Class I Division 1 Group D in hazardous areas.

E. FLX Fittings:

1. Provide insulated die-cast clamp-on type connectors.
2. Binding screw connectors are not acceptable.

F. SLT Fittings:

1. Construction:
   a. Malleable iron.
   b. Furnished with locknut and sealing ring.
   c. Liquid-tight, rain-tight, oil-tight.
   d. Insulated throat.
   e. Furnish as straight, 45-degree elbows and 90-degree elbows.
   f. Designed to Prevent Sleeving: Verify complete bonding of the raceway jacket to the plastic gasket seal.
   g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled over edges for sizes under 5 inches.
   h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
2. Corrosion Resistant and Outdoor SLT fittings:
   a. Construction:
      1) PVC-coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
      2) Insulated throat and an integral sealing ring.
3. ST fittings shall only be used in Class 1, Division 2 locations.

G. All conduits shall use threaded hubs for connections to sheet metal enclosures.

1. Construction:
   a. Insulated throat.
   b. PVC coated when used in corrosive areas.
   c. Bonding locknut.
   d. Recessed neoprene O-ring to assure watertight and dust-tight connector.
   e. 1/2-inch through 6-inch steel zinc electroplated.
   f. Aluminum with aluminum conduit.

H. Sealing Fittings:

1. Construction:
   a. 40 percent wire fill capacity.
   b. Shall be rated for horizontal and vertical installations.
   c. PVC-coated when used in corrosive areas.
   d. Malleable iron with steel conduit.
   e. Aluminum with aluminum conduit.
   f. Crouse-Hinds Type EYD where drains are required.
   g. Crouse-Hinds Type EYS where drains are not required.
   h. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; Class II, Division 1 and Division 2; Groups E, F, and G.
2. Sealing Compound:
   a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
   b. Approved for the conditions and use. Not affected by surrounding atmosphere or liquids.
   c. Melting point shall be 200 degrees F minimum.

I. PVC Fittings:

1. Shall include the following:
   a. Couplings.
   b. Terminal adapters.
   c. Female adapters.
   d. Caps.
   e. Reducer bushings.
   f. Duct couplings.
   g. End bells.
   h. Expansion couplings.
   i. Duct couplings 5 degree.
   j. C-pull fittings.
   k. E-pull fittings.
   l. LB-pull fittings.
   m. LL-pull fittings.
   n. LR-pull fittings.
   o. T-pull fittings.
   p. X-pull fittings.
   q. Service entrance caps.
2. Materials:
   a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
   b. All metal hardware shall be stainless steel.

J. EMT Fittings: Rain-tight compression fittings only. The use of set-screw connectors shall not be permitted. Connectors shall have insulated throat.

K. Through Wall and Floor Seals:

1. Materials:
   a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
   b. Grommet: Neoprene.
   c. Pressure Rings: PVC coated steel.
   d. Disc Material: PVC coated steel.
   e. Aluminum when used with conduit Type RAC.

L. Expansion/Deflection Couplings:

1. Use to compensate for movement in any directions between two conduit ends that they connect.
2. Shall allow movement of 3/4 inch from the normal in all directions.
3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
4. Constructed to maintain electrical continuity of the conduit system.
5. Materials:
   a. End Couplings: Bronze or galvanized ductile iron.
   b. Sleeve: Neoprene.
   c. Bands: Stainless steel.
   d. Bonding Jumper: Tinned copper braid.

M. Expansion Couplings:

1. Shall allow for expansion and contraction of conduit. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system.
3. Materials:
   a. Head: Malleable or ductile iron.
   b. Sleeve: Steel.
   c. Insulating Bushing: Phenolic.
   d. Finish: Hot-dip galvanized.
   e. Aluminum when used with conduit Type RAC.

N. Conduit Markers: As specified in Section 16075, Electrical Identification.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

B. General:

1. Conduit Routing:
    a. The Electrical Drawings are Diagrammatic in Nature:
        1) Install conduit runs as specified with schematic representation as indicated on the Drawings and as specified.
        2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
            a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
            b) Make changes in conduit routing due to the relocation of equipment.
        3) The Electrical Drawings do not indicate all required junction boxes and pull boxes:
            a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
                (1) To meet cable manufacturer’s pulling tension requirements.
                (2) To limit total conduit bends between pull locations.
            b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
    b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the circuit/raceway block diagrams without the express written approval or direction by Engineer:
        1) The Engineer is the sole source in determining whether the change is constituted as a deviation.
        2) Perform any changes resulting in additional conduits, or extra work from such deviations.
        3) Incorporate any deviations on the Record Documents.
    c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on the Record Drawings.

2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
    a. Clearances of 6 inches from surfaces 113 degrees F to 149 degrees F.
    b. Clearances of 12 inches from surfaces greater than 149 degrees F.
    c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
    d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8 inch away from wall on an accepted preformed channel: Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1 inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
    a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
    b. Make changes in direction with long radius bends or conduit bodies.
7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.
8. Max total conduit distance between boxes or conduit body 250 feet.
9. Route all exposed conduit to preserve headroom, access space and workspace and to prevent tripping hazards and clearance problems:
    a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment removal hatches.
    b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.
10. Conduit may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings: Refer to the typical details for conduit spacing and size requirements.
11. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use GPR or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, etc.
12. Duct seal conduits brought into pull boxes, manholes, handholes, panels, PLC cabinets, and other openings until used to prevent entrance of moisture.

13. Install conduit through wall and floor seals where indicated on the Drawings.
14. For existing and new 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
    a. Remove and replace conduits through which mandrel will not pass.
15. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
16. Install complete conduit systems before conductors are installed.
17. Provide metallic conduits terminating in transformer, switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with a minimum 6 AWG ground wire.
18. Underground and Embedded Conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. All conduits coming out of grade shall have a cap installed, (not tape) during backfill and concrete pouring. Remove only to extend to final location.

C. Lighting and Receptacle Conduits:

1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
    a. Minimum Conduit Size:
        1) 3/4 inch for exposed conduits.
        2) 1 inch for underground or in slab conduits.
2. Provide conduit materials for the installed location as specified in Section 16050, Common Work Results for Electrical.

D. Hazardous Areas: As specified in Section 16050, Common Work Results for Electrical, for hazardous areas and specific Class and Division.

E. Conduit Usage:

1. Exposed Conduits:
   a. Rigid Conduit:
      1) Install the rigid conduit type for each location as specified in Section 16050, Common Work Results for Electrical.
      2) Minimum Size: 3/4 inch.
   b. Flexible Conduit:
      1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:
         a) Use Type SLT with rigid metallic conduit.
            (1) Indoors use gray.
            (2) Outdoors use black.
         b) Use Type NFC with PVC conduit.
         c) Use Type EFLX in Class I, Division 1 locations.
         d) Use Type FLX in finished areas.
      2) Minimum Size: 3/4 inch.
         a) 1/2 when required for connection to instruments.
      3) Maximum Length:
         a) Fixed Equipment:

Conduit Trade Size	Flexible Conduit Length (in)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

         b) Removable Instruments or Hinged Equipment: As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete Encased and Concrete Capped Embedded Conduits:
   a. Type PVC Schedule 40 and PVC coated rigid metallic conduit as specified below:
      1) Use Type PCS in underground and embedded installation as follows:
         a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
         b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished floor.
         c) For any and all bends where the total deflection is greater than 45 degrees.
   b. Minimum Size:
      1) 2 inches in duct banks unless otherwise indicated on the Drawings.
      2) 1 inch for in slab conduits unless otherwise indicated on the Drawings.
   c. Direct Buried and Sand Bedded Ductbank Conduits:
      1) Type PCS.
      2) Minimum Size: 1 inch.
3. PVC Coated Rigid Metallic Conduit: Use specifically manufactured or machined threading dies to manufacturer’s specifications to accommodate the PVC jacket.
4. GRC: Conduit shall be cut square and reamed before threading.
5. PVC:
   a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
   b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box. Use a locknut on the inside of the box to tighten the adapter to the box.

F. Conduit Joints and Bends:

1. General:
   a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA Type 4 or NEMA Type 4X locations, make joints liquid-tight.
   b. Keep bends and offsets in conduit runs to an absolute minimum.
   c. All bends shall be symmetrical.
   d. For all types of high-voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter.

e. The following conduit systems shall use large radius sweep elbows:
   1) All conduits trade size 1-1/4 inches and larger.
   2) Exception shall be lighting and receptacle branch circuit conduits.
f. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.
g. Make field bends with a radius of not less than the requirements found in the NEC:
   1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
   2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
      a) Make bends so that the conduit is not damaged, and the internal diameter is not effectively reduced.
      b) For the serving utilities, make bends to meet their requirements.
h. Replace all deformed, flattened, or kinked conduit.

2. Threaded Conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar” or CRC “Zinc It.”
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit.
      2) Apply to the male threads and tighten joints securely.
      3) Clean excess sealant from exposed threads after assembly.

f. Securely tighten all threaded connections.
g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.
   b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends: Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit Sealing and Drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:
   a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
   b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.
   c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
      1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
   d. Provide conduit seals similar to O/Z Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
   e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, “or-equal.”
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pullboxes, or low points of conduit.
3. All conduits which enter/leave a building shall be sloped away from the building to prevent the accumulation of water within the building.
4. All conduits which enter/leave a building shall be sealed with an approved duct seal.

H. Conduit Supports:

1. General:
   a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
      1) As specified in Section 16070, Hangers and Supports.
      2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050, Common Work Results for Electrical.
   b. Support conduit at the intervals required by the NEC.
   c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Finished Areas:
   a. Above Suspended Ceilings:
      1) Support conduit on or from the structure, do not support conduit from hanging wires or suspended ceiling grid.
      2) Provide independent hanger wires for all conduits.
      3) Identify the hanger wires using red spray paint.

I. Expansion or Expansion/Deflection Fittings:

1. General:
   a. Align expansion coupling with the conduit run to prevent binding.
   b. Follow manufacturer’s instructions to set the piston opening.
   c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
   d. Furnish fittings of the same material as the conduit system.
2. For metallic conduit (PCS, PCA, GRC and RAC) provide expansion or expansion/deflection couplings, as appropriate, where:
   a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
   a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
   b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

J. Empty Conduits:

1. Provide a “true tape” measuring tape rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.

2. Provide one empty 3/4-inch conduit for each four spare unused circuits or spaces of each flush mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.
3. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation. Keep ends sealed until immediately before pulling conductors.

K. PCS Damaged Conduits: PCS conduits that have damaged PVC coating shall be replaced, no exceptions. Field repair shall not be acceptable.

L. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled: Running threads and threadless couplings are not allowed.
3. Replace any conduit installed that the Engineer determines does not meet the requirements of this specification.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16134
BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Device boxes.
2. Raceway system boxes.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM):
   a. A47, Standard Specification for Ferritic Malleable Iron Castings.
   b. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   c. D495, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
   d. D570, Standard Test Method for Water Absorption of Plastics.
   e. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
g. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

3. Joint Industry Conference (JIC).
4. UL: 94, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Arcing Parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
2. Raceway System Boxes: Boxes that are used for wire and cable pull-boxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pull-boxes for use in the raceway systems, etc.

B. Provide boxes and conduit bodies as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer.
2. Materials.
3. Dimensions:
   a. Height.
   b. Width.
   c. Depth.
   d. Weight.
   e. NEMA rating.

4. Conduit entry locations.
5. Catalog cut sheets.
6. Installation instructions.

C. Shop Drawings: Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. Outlet boxes shall comply with all applicable standards of:
   a. JIC.
   b. NEC.
   c. NEMA.
   d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 SEQUENCING

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Pressed Steel Boxes:
   a. Steel City.
   b. Appleton.

c. Crouse - Hinds.
d. Thomas & Betts.
e. “Or-equal.”

2. Concrete Boxes:
   a. Appleton.
   b. Steel City.
   c. Cooper/Crouse Hinds.
   d. OZ Gedney.
   e. “Or-equal.”
3. Threaded-hub Boxes:
   a. Appleton.
   b. Crouse - Hinds.
   c. OZ/Gedney.
   d. “Or-equal.”
4. Plastic-coated Steel Boxes:
   a. Rob Roy.
   b. OCAL.
   c. “Or-equal.”
5. Cast Device Boxes:
   a. Appleton.
   b. Crouse - Hinds.
   c. OZ/Gedney.
   d. “Or-equal.”
6. Formed Steel Enclosures:
   a. Hoffman.
   b. Thomas and Betts.
   c. Stahlin.
   d. Rittal.
   e. Saginaw.
   f. “Or-equal.”
7. Stainless Steel Enclosures:
   a. Hoffman.
   b. Stahlin.
   c. Rittal.
   d. Saginaw.
   e. “Or-equal.”
8. In-Ground Junction Boxes: Old Castle.

2.02 MANUFACTURED UNITS

A. Pressed Steel Boxes:

1. One-piece galvanized pressed steel.
2. Knockout type boxes.
3. Minimum size 4 inches square by 2-1/8 inches deep.

B. Threaded-hub Boxes:

1. Construction:
   a. With internal green ground screw.
   b. Furnished with a suitable gasketed cover.
   c. With integral cast mounting lugs when surface mounted.
   d. Conduit sizes range from 3/4 inch to 1 inch.
   e. Tapered threaded hubs with integral bushing.
   f. Shall be FD-Type, 2.69 inches deep minimum with mounting lugs and integral grounding screw.
2. Malleable Iron Boxes: Conforming to ASTM A47, Grade 32510.

C. Plastic-Coated Threaded-Hub Boxes:

1. Construction:
   a. With internal green ground screw.
   b. Furnished with a suitable gasketed cover.
   c. With integral cast mounting lugs when surface mounted.
   d. Conduit sizes range from 3/4 inch to 1 inch.
   e. Shall be FD-Type, 2.69 inches deep minimum with mounting lugs and integral grounding screw.
   f. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
   g. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
   h. With pressure sealing sleeve to protect the connection with conduit.

D. Class I, Division 1 Areas:

1. Provide boxes designed and listed for Class I, Division 1 locations and group type atmosphere in which they will be used.
2. The approval ratings must be permanently marked on each item.

E. Class I, Division 2 Areas:

1. For Boxes not Containing Arcing Parts:
   a. As specified in Section 16050, Common Work Results for Electrical.
   b. Pressed metal boxes are not allowed.
2. For boxes containing arching parts provide:
   a. Boxes designed and listed for Class I, Division 1 locations and group type atmosphere in which they will be used:
      1) The approval ratings must be permanently marked on each item.
3. Cast iron box and cover.

4. Precision machined flame path between box and cover with neoprene O-ring.
5. Bolt-on stainless steel slotted mounting feet for horizontal or vertical mounting.
6. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
7. External flange.
8. Shall be provided with manufacturer supplied backpanel.
9. Ground lug.

F. Formed Steel Enclosures:

1. Steel:
   a. NEMA Type 12.
   b. Fabricated from 14-gauge steel, minimum.
   c. All seams continuously welded ground smooth.
   d. Door:
      1) Rolled lip around three sides.
      2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      3) The door is secured with a flush quarter-turn latch (coin style).
   e. Neoprene door gasket to provide a watertight, dust-tight, oil-tight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
      3) Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel with a hasp and staple for padlocking.
   f. Provide large enclosures with door and body stiffeners for extra rigidity.
   g. No holes or knockouts.
   h. Finish:
      1) ANSI 61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
      2) White electrostatically applied polyester powder mounting plate.
   i. Heavy gauge steel external mounting brackets when surface mounted.
   j. Shall be provided with manufacturer supplied backpanel.
   k. Provide manufacturer supplied hinged deadfront as shown on the Drawings.

2. Stainless Steel:
   a. NEMA Type 4X:
      1) Boxes in locations subject to flooding or temporary submersion: NEMA Type 6.
   b. Fabricated from 14-gauge Type 316 stainless steel.
   c. All seams continuously welded.
   d. Door:
      1) Rolled lip around three sides.
      2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
      3) The door is secured with a flush quarter-turn latch (coin style).
   e. Neoprene door gasket to provide a watertight seal:
      1) Attached with an adhesive.
      2) Retained by a retaining strip.
   f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel with a hasp and staple for padlocking.
   g. Provide large enclosures with door and body stiffeners for extra rigidity.
   h. No holes or knockouts.
   i. Finish: Brushed.
   j. Stainless steel external mounting brackets when surface mounted.
   k. Shall be provided with manufacturer supplied backpanel.
   l. Provide manufacturer supplied hinged deadfront as shown on the Drawings.
   m. In-ground Junction Boxes:
      1) Suitable for use outdoors where subject to rain, dripping, or splashing water.
      2) Designed for flush mounting in grade.
      3) Minimum dimensions 13 inches by 24 inches by 12 inches deep.
      4) Construction:
         a) Concrete polymer.
         b) Covers:
            (1) Concrete polymer flush covers suitable for H20 incidental traffic loads.
            (2) Cover shall have verbiage molded into the top identifying the type of service served such as electric, fiber optic, communications, etc.
            (3) Stainless steel screw covers.

2.03 ACCESSORIES

A. Fasteners:

1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, Nuts, Bolts, and Other Threaded Fasteners: Stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. General:

1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050, Common Work Results for Electrical, Paragraph Plant Area Electrical Work Requirements.
2. Provide outlet box materials to match the conduit system:
   a. RGS: Painted cast ferrous boxes.
   b. PVC coated RGS: PVC coated cast ferrous boxes.
   c. PVC: PVC boxes.
   d. RAC: Aluminum cast boxes.
3. Solid Type Gang Boxes:
   a. For more than two devices.
   b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
   a. Use machined spacers to maintain air space; built-up washers are not acceptable.
   b. Use stainless steel or nylon materials for spacers.
5. In Finished Areas: Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
6. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
7. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120V discrete or power wiring.
8. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
9. All boxes and enclosures installed outdoors shall have hinges installed on the sides of the enclosure. No hinges on the top of the box or enclosure shall be permitted.

10. Conduits shall not enter the top of boxes in wet locations or in locations where subject to water.

C. Outlet Boxes:

1. Locate outlet boxes as indicated on the Drawings: Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub, FD-type, malleable iron, or aluminum boxes:
   a. In hazardous areas.
   b. Where exposed to the weather.
   c. In unheated areas.
   d. Where subject to mechanical damage: Defined as exposed boxes less than 10 feet above the floor.
   e. To act as a pull box for conductors in a conduit system.
   f. Accommodate wiring devices.
3. Use deep threaded-hub, FD-type, plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.

D. Pull Boxes and Junction Boxes: Install pull boxes so they are accessible as defined by the NEC.

E. For Boxes Not Indicated:

1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050, Common Work Results for Electrical.
2. Outlet, Switch, and Junction Boxes for Flush-mounting in General Purpose Locations: One-piece, galvanized, pressed steel.
3. Ceiling Boxes for Flush Mounting in Concrete: Deep, galvanized, pressed steel.
4. Outlet, Switch, and Junction Boxes where Surface Mounted in Exposed Locations: Cast ferrous boxes with mounting lugs, zinc, or cadmium plating finish.
5. Outlet, Control Station, and Junction Boxes for Installation in Corrosive Locations:
   a. PVC, stainless steel, or plastic-coated steel as specified in Section 16050, Common Work Results for Electrical.
   b. Furnished with mounting lugs.

F. Recessed Boxes:

1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
2. Secure hangers or boxes to wood with 1-inch long cadmium-plated Type A pan head screws: Fully or partially hammer-driven screws are not acceptable.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Switches.
2. Receptacles.
3. Plates.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. Federal Specifications (FS):
   a. W-C 596, Connector, Electrical, Power, General Specification for.
   b. W-S 896/2, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. National Electrical Manufacturers Association (NEMA):
   a. WD1, General Color Requirements for Wiring Devices.
   b. ICS 5, Industrial Control and Systems, Control Circuit and Pilot Devices.
   c. OS1, Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   d. WD6, Wiring Devices Dimensional Specifications.

4. UL:
    a. 20, General Use Snap Switches.
    b. 498, Standard for Attachment Plugs and Receptacles.
    c. 514D, Cover Plates for Flush-Mounted Wiring Devices.
    d. 943, Ground-Fault Circuit-Interrupters.
    e. 1472, Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Cooper: Cooper Wiring Devices, a division of Cooper Industries.
2. GFCI: Ground fault circuit interrupter.
3. P-S: Pass and Seymour.
4. T&B: Thomas and Betts.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data: Catalog cut sheets.

C. Shop Drawings:

1. Engraving Schedule: Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Switches:

1. One of the following:
   a. Hubbell.
   b. Leviton.
   c. Cooper.
   d. “Or-equal.”
2. Switches for Hazardous Areas:
   a. One of the following:
      1) Appleton.
      2) Crouse-Hinds.
      3) “Or-equal.”
3. Twist Timer:
   a. One of the following:
      1) Intermatic.
      2) “Or-equal.”

B. Receptacles:

1. General Purpose Receptacles:
   a. One of the following:
      1) Hubbell.
      2) Leviton.
      3) Cooper.
      4) “Or-equal.”
2. Receptacles for Hazardous Areas:
   a. One of the following:
      1) Crouse-Hinds.
      2) Appleton.
      3) “Or-equal.”

C. Single-Ended Cordset:

1. The following:
   a. Brad Harrison.
   b. “Or-equal.”

D. Plates:

1. General Location:
   a. One of the following:
      1) P-S.
      2) Cooper.
      3) “Or-equal.”
2. Wet or Corrosive Areas:
   a. One of the following:
      1) Hubbell.
      2) Cooper.
      3) T&B.
      4) P-S.
      5) “Or-equal.”
3. Metal Heavy-duty In-use Covers:
   a. One of the following:
      1) TayMac.
      2) Cooper.
      3) P-S.
      4) T&B.
      5) “Or-equal.”

2.02 MANUFACTURED UNITS

A. Switches:

1. General:
   a. 120V ac to 277V ac.
   b. 20 amperes.
   c. Listed in accordance with UL 20.
   d. Designed and constructed in accordance with FS W-S-896/2.
   e. Specification grade, unless otherwise noted.
   f. Integral grounding terminal.
   g. Totally Enclosed: Color-coded body with color corresponding to ampere rating.
   h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.

i. Color:
1) Ivory in finished areas.
2) Gray in all other areas.

2. General Purpose Switches: Toggle type.
3. Switches for Hazardous Areas:
a. Suitable for use in Class I, Division 1 and Class I, Division 2 locations.
b. Factory sealed.
c. Through-feed or dead-end as required.
4. Astronomic Timer:
a. 7 Day in-wall switch.
b. Automatic Daylight Savings time.
c. Manual over-ride.
d. Battery backup.
5. Twist Timers:
a. Stainless steel faceplate.
b. Twist-style, spring-wound.
c. 2 hours with 5-minute intervals marked on faceplate.
d. Commercial-grade.

B. Receptacles:

1. General Purpose Receptacles:
a. Single or duplex as indicated on the Drawings.
b. 125V ac.
c. 20 amperes or as indicated on the Drawings.
d. NEMA Type 5-20R configuration for 20-ampere receptacles.
e. Other NEMA configurations as indicated on the Drawings.
f. Listed in accordance with UL 498.
g. Designed and constructed in accordance with FS W-C-596.
h. Specification grade.
i. One-piece, rivet-less mounting strap.
j. Color:
1) Ivory in finished areas.
2) Brown in all other areas.
3) Orange when powered by a UPS.
2. Ground Fault Interrupter Receptacles (GFCI):
a. 125V ac.
b. 20 amperes.
c. Trip level 4 milliampere to 6 milliampere.
d. Individual and feed through protection.
e. UL 943 and UL 498 listed.
f. NEMA Type 5-20R configuration.
g. Weather resistant, in accordance with UL 498.

3. 480-volt three-phase Receptacles:
    a. 480 volt, 30 amp, 10 hp.
    b. Switch rated.
    c. Three-pole plus ground.
    d. IP66/67 and NEMA 4X rated.
    e. Provide with two auxiliary/pilot contacts.
    f. Provide with manufacturer supplied FD-Type junction box and 30-degree nylon angle.
4. 480-Volt Three-phase Inlet:
    a. 480-volt, 30-amp, 10 hp.
    b. Compatible and of the same manufacturer as the 480-volt three-phase receptacle.
    c. Switch rated.
    d. Three-pole plus ground.
    e. IP66/67 and NEMA 4X rated.
    f. Provide with two auxiliary/pilot contacts.
    g. Provide poly handle with 3/4-inch NPT.

C. Single-Ended Cordsets:

1. 16 AWG CU yellow STOOW cable with US color code.
2. Oil resistant PVC jacket.
3. Non-metallic coupling nut.
4. 6-foot cable length minimum.
5. Available in two-pole through six-pole. Provide cordsets with number of poles as shown on the Drawings.
6. Provide straight end connectors, male and female receptacles.

D. Plates:

1. General Location:
    a. Type 302 or Type 304 stainless steel.
    b. Brushed satin finish.
    c. Minimum Thickness: 0.032 inch.
    d. Rectangular or square shape.
    e. Labeling:
        1) Provide each switch plate with the following:
            a) Panel (source).
            b) Circuit number.
            c) Refer to CWS Equipment Tag Numbering Standards.
        2) Characters shall be block letter pantograph engraved with a minimum character height of 1/8 inch.
    f. Coordinate the number of gangs, number, and type of openings with the specific location.

2. Outdoor and Wet Areas Requiring NEMA Type 4 or NEMA Type 4X Enclosures:
   a. General:
      1) UL listed for wet locations.
      2) Gasketed.
      3) Die Cast Metal: Match material to box material.
   b. Switches:
      1) Lever Operated: Provide toggle switch.
      2) Carlon E98TSCN In-use cover.
      3) Three-pole motor toggle: Leviton Cover-S.
   c. Receptacles:
      1) Weatherproof In-use Cover:
         a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
         b) Gasketed.
         c) Lockable.
         d) UL listed and in accordance with NEC.
3. Corrosive Areas:
   a. Neoprene.
   b. Gasketed.
   c. Weatherproof.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Mounting Heights:

1. Process and Production Areas: Switches and receptacles 48 inches from finished floor to top of plate.

C. Switches:

1. Over 300 Volts: Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:

1. Provide GFCI receptacles as indicated on the Drawings.
   a. Provide weather resistant GFCI receptacles in all wet or damp areas. As specified in Section 16050, Common Work Results for Electrical.

2. Mount Non-weatherproof Receptacles Vertically: Ground slot down.
3. Mount Weatherproof Receptacles Horizontally: Neutral slot up.
4. Three-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

E. Single-Ended Cordsets: Provide single-ended cordsets as the disconnecting means for wiring to instrument transmitters.

F. Ensure all plates make a firm seal with wall for recessed mounted devices: Outside edges of plates parallel with building lines.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Demonstrate the following to the Engineer and Owner:

1. Switching is as indicated on the Drawings.
2. All circuits conform to the Panel Schedules.
3. All ground fault receptacles operate at levels below or equal to OSHA maximum allowable fault levels.

3.04 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16150
LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wire connecting devices.
2. Terminations.
3. Splices: Splice are not allowed unless submitted, reviewed, and approved by Owner prior to installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. ASTM International (ASTM): D3005, Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
3. CSA International (CSA): C22.2, No.197-M1983 (R2208) - PVC Insulating Tape.
4. UL: 510, Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Catalog cut sheets.
2. Installation instructions.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this section.

2.02 EQUIPMENT

A. Control Connections:

1. Use insulated ring type wire terminators for connections to all screw terminals:
   a. With chamfered/funneled terminal barrel entry.
   b. Deep internal serrations.

c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
d. Electroplated-tin copper conductor.
e. Manufacturers:
1) One of the following:
a) Thomas and Betts, Stakon.
b) "Or-equal."
2. For process equipment connections work from manufacturer's drawings.

B. Joints, Splices, Taps, and Connections:

1. All crimp connections shall use long barrel type.
2. 600-Volt Conductors:
a. Use solderless connectors.
b. Use only plated copper alloy connectors or lugs: Aluminum connectors or lugs are not acceptable for copper conductors.
c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
d. For wire 10 AWG and smaller, use compression splice caps, with insulating caps:
1) Manufacturer and Product:
a) The following:
(1) Ideal; winged wire connectors.
(2) "Or-equal."
e. For wire 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturers:
a) One of the following:
(1) Burndy.
(2) Thomas and Betts.
(3) "Or-equal."
f. Heat Shrink Tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum Shrink Ratio: 4 to 1.
3) Continuous Operating Temperature: Minus 55 degrees C to 110 degrees C.
4) Internally applied adhesive sealant.

5) Cross-linked Polyolefin:
a) Manufacturers:
(1) One of the following:
(a) 3M ITCSN.
(b) Thomas & Betts Shrink-Kon.
(c) "Or-equal."

3. Instrumentation Class Cable Splices:
a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
d. Two-part mold body with tongue and groove seams and built in spacer webbing.
e. Manufacturer and Product:
1) The following:
a) 3M; Scotchcast 72-N.
b) "Or-equal."

C. Insulating Tape:

1. General Purpose Insulating Tape:
a. Minimum 7-mil vinyl tape.
b. Suitable for application in an ambient of minus 18 degrees C (0 degree F).
c. Operating range up to 105 degrees C (220 degrees F).
d. Flame retardant, hot- and cold- weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600V ac.
f. Meeting and complying with:
1) ASTM D3005, Type I.
2) UL 510.
3) CSA C22.2.
g. Manufacturer and Product:
1) The following:
a) 3M; Scotch Number Super 88.
b) "Or-equal."
2. General Purpose Color-coding Tape:
a. Minimum 7-mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.

4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.

e. For use as phase identification, marking, insulating, and harnessing.
1) Meeting and complying with:
a) UL 510.
b) CSA C22.2.

f. Manufacturer and Product:
1) The following:
a) 3M; Scotch Number 35.
b) “Or-equal.”

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Load Connections: Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123, 600-Volt or Less Wires and Cables.

C. Zero to 600-Volt Systems:

1. Make all connections with the proper tool and die as specified by the device manufacturer.
2. Use only tooling and dies manufactured by the device manufacturer.
3. Insulate all connections and splices with Scotch Super 88 tape and Scotchfill, or premolded plastic covers, or heat shrink tubing and caps.
4. Number all power and control wires before termination.
5. Apply 4 inches of heat shrink between cable and loose wiring on all multi conductor cable after removing the outer jacket.

D. Motor Connections (600 volts and below):

1. Terminate wires with compression type ring lugs at motors.
2. Connection at both the motor leads and the machine wires shall have ring type compression lugs.

3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
   a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
   b. Shrink cap with low heat as recommended by manufacturer.
4. Wire markers shall be readable after boot installation.
5. Manufacturer and Product:
   a. The following:
      1) Thomas & Betts; Motor Boot, MSC style.
      2) “Or-equal.”

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16222
LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Low Voltage Motors up to 500 hp:
   a. Furnished separately.
   b. Part of driven equipment specified in other sections.
   c. Other electric motors required for a complete installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.
   c. Section 16950, Field Electrical Acceptance Tests.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
3. American Petroleum Institute (API): 670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
4. ASTM International (ASTM): B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.

5. Institute of Electrical and Electronic Engineers (IEEE):
   a. 43, IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   b. 112, IEEE Standard Test Procedure for Poly-phase Induction Motors and Generators.
   c. 114, Standard Test Procedure for Single-Phase Induction Motors.
   d. 303, Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations.
   e. 841, Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500hp).
   f. 1349, Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.
6. National Electrical Manufacturers' Association (NEMA):
   a. MG-1, Motors and Generators.
   b. MG-2, Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.
7. UL: 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this section and the sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Submit completed motor data sheets for each motor supplied:

   1. Conform to data sheet in the appendix of this section.
   2. Manufacturers or other data sheets are not acceptable.

C. Product Data:

1. Descriptive bulletins.
2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
3. Complete electrical data.
   a. Rated size of motor, hp, and service factor.
   b. Efficiency at full, 3/4 and 1/2 load.
   c. Full load current.
   d. Locked rotor current.
4. Temperature rise and insulation rating.
5. Type of bearing.
6. Torque, Current, and Power Factor versus Speed Curves:
   a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
   b. For motors on reduced voltage start at 70 percent, 80 percent, 90 percent, and 100 percent rated voltage.
7. Additional Data for Motors Installed in Classified Areas:
   a. Temperature code.
   b. Hazardous area approval indicating Class, Division, and Group:
      1) For motors driven by variable frequency drives, provide manufacturer’s certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.
8. Accessories Data:
   a. Power Factor Correction Capacitors: Size in KVAR, for all motors not connected to variable frequency drives.
   b. Winding Temperature Detectors:
      1) Type.
      2) Rating.
      3) Moisture detectors.
9. Mechanical Data:
   a. Bearing design and bearing life calculations.
   b. Resonant frequencies for all VFD-driven motors 50 hp or greater.
10. List of manufacturer’s recommended spare parts.

D. Shop Drawings:

1. Motor weight.
2. Frame size.
3. Conduit box (es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Test Reports: Factory test reports with test reference standard identified.

F. Certification:

1. When motors are driven by variable speed drive systems, submit certification that selected motor:
   a. Is capable of satisfactory performance under the intended load.
   b. Meets the requirements of the latest edition of NEMA MG-1, Part 31.
   c. Is matched to the type of variable frequency drive specified.

G. Calculations: Where site conditions specified in Section 16050, Common Work Results for Electrical, exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Motors 200 hp and Larger: Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Nidec/US Motors.
2. WEG.

3. ABB/Baldor/Reliance.
4. “Or-equal.”

2.02 EQUIPMENT

A. Three-phase Induction Motors, General:

1. Voltage: All motors 1/2 hp and larger shall be rated 460V, three-phase unless otherwise as indicated on the Drawings.
2. Motors driving identical machines shall be identical.
3. All motors greater than 1 hp and up to 500 hp shall meet the “NEMA Premium Efficiency” percent listed in NEMA MG-1.
4. Horsepower as indicated on the Drawings:
   a. Horsepower ratings as indicated on the Drawings are based on vendor’s estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
5. Service Factor:
   a. 1.15 service factor on sine wave power.
   b. 1.0 when driven by VFD.
6. Torque:
   a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
   b. When started using reduced voltage starters: Provide motors that develop sufficient torque for acceleration to full speed.
   c. NEMA Design B except where driven load characteristics require other than normal starting torque: In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
   a. As specified in the individual equipment specifications or in this section.
   b. Totally Enclosed Fan Cooled:
      1) Cast iron conduit box.
      2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
   c. Explosion-Proof: Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
   d. Lifting Devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer’s standard material for the specified rating.

9. Nameplates:
    a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
        1) NEMA standard motor data.
            a) Indicate compliance with NEMA MG-1, Part 31 for inverter duty motors.
        2) AFBMA bearing numbers and lubrication instructions.
10. Hardware: Type 316 stainless steel.
11. Conduit Boxes:
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
        1) Frames and conduit boxes.
        2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments. Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1. The main conduit box shall be oversized at least one size larger than NEMA standard. The main conduit box shall be sized for all indicated accessory leads. Motor furnished in NEMA 320 frame series and larger shall have conduit boxes designed and constructed to permit motor removal after installation without disconnecting raceways.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor Bearings:
    a. Antifriction.
    b. Oil-mist lubrication type for all applicable motors above 50 hp. Bearing mounting shall be deigned to prevent entrance of lubricant into the motor enclosure.
    c. Where oil-mist lubrication is not possible, provide regreasable type lubrication. Initially fill with grease. Provide permanently sealed bearings for motors 50 hp and below.
    d. Bearings and lubrication suitable for ambient temperature and temperature rise.
    e. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
    f. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
    g. Where specified in the equipment specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.

13. Insulation Systems:
    a. Motors Insulation:
        1) Provide Class H insulation.
        2) Design temperature rise consistent with Class H insulation.
        3) Rated to operate at an ambient temperature of 65 degrees C at the altitude where the motors will be installed.
14. Motor Leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
    b. All motors rated 100 hp and larger, and all vertical motors shall have the direction of rotation marked by an arrow mounted visibly on the stator frame near the terminal housing, or on the nameplate, and the leads marked for phase sequence T1, T2, T3, to correspond to the direction of rotation and supply voltage sequence. Permanent instructions for making these connections shall be furnished inside the main conduit box or on the motor frame or nameplate.
    c. Motor leads shall be provided with single hole compression lugs.
15. Noise: Maximum operating noise level in accordance with NEMA MG-1.

B. Motors Driven by Variable Frequency Drives (VFD):

1. Compatible with the variable frequency drives specified.
2. Inverter duty rated and labeled.
3. Meet the requirements of NEMA MG-1, Part 31.
4. Winding insulation meets the requirements of NEMA MG-1, Part 31.4.4.2.
5. Capable of running continuously at 1/10th of full speed, with no harmful effects of overheating.
6. Shaft Grounding Ring:
    a. Provide a shaft grounding ring for each VFD driven motor.
    b. Aluminum frame and internal components.
    c. Conductive microfiber brushes.
    d. Maintenance free design.
    e. Aegis Bearing Protection ring as manufactured by Electro Static Technology, “or-equal.”
7. In addition to the requirements of NEMA MG-1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1,600V ac.

C. Motors Installed in Hazardous Locations:

1. Class I, Division 1 or Class II, Division 1 Areas:
   a. Enclosures:
      1) Explosion proof for three-phase motors.
      2) UL listed in conformance with UL 674.
      3) UL approval with nameplate and serial number.
2. Other Hazardous Areas:
   a. Enclosures:
      1) TEFC for motors in Class I, Division 2 areas.
      2) Vertical motors as specified herein.
      3) Hazardous area and temperature code approval stamped on nameplate.
3. Single-Phase Motors: Explosion proof motor enclosure.

D. Motors Installed in Corrosive Environments:

1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of two coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.
6. Suitable for hose down areas.

E. Integral Overload Protection.

F. Motors Installed in Corrosive Environments:

1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of two coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.
6. Suitable for hose down areas.

2.03 ACCESSORIES

A. Motor Winding Heaters:

1. Provide winding heaters only where specified or as shown on the Drawings.
2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.

3. Power leads for heaters wired into conduit box.
4. Installed within motor enclosure adjacent to core iron.

B. Winding Temperature Detectors:

1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
   a. Where required by the driven equipment specification or as indicated on the Drawings.
2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.04 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Motors Less than 250 hp:
   a. Perform manufacturer's standard production tests including, but not limited to:
      1) No load current.
      2) High potential test.
      3) Winding resistance.
      4) Core loss on motor rewinds.
   b. Furnish copies of standard test reports on prototype or identical units.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install motors in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Before startup, perform insulation resistance test on each motor furnished or installed on this Project:

1. Windings energized to 1,000V dc for 1 minute.
2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.

3. Inform the Engineer of any unusual or unacceptable test results.
4. This test is in addition to the acceptance tests in Section 16950, Field Electrical Acceptance Tests.

3.03 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Motor Data Sheet.

END OF SECTION

MOTOR DATA SHEET

MOTOR/EQUIPMENT TAG

MOTOR NUMBER SPECIFICATION NUMBER OF DRIVEN MACHINE

MOTOR NAMEPLATE DATA

MANUFACTURER MODEL/SERIES MODEL NO.

FRAME ENCLOSURE NEMA DESIGN HP

SERVICE FACTOR

RPM INSULATION CLASS

VOLTS FULL LOAD AMPS

AMBIENT TEMP PHASE NO LOAD AMPS

DESIGN TEMP RISE HERTZ

LOCK ROTOR AMPS INRUSH CODE LETTER

100% LOAD 75% LOAD 50% LOAD

GUARANTEED MINIMUM EFFICIENCIES:

GUARANTEED MINIMUM POWER FACTOR:

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: KVAR

ACCESSORIES

MOTOR WINDING HEATER VOLTS

WATTS WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO) RTD:

TYPE

QUANTITY PER PHASE

OF WIRES NOMINAL RESISTANCE NOMINAL TEMP COEFFICIENT RECOMMENDED ALARM °C RECOMMENDED TRIP °C
SPECIAL APPLICATIONS INVERTER DUTY* (YES/NO) PART WINDING (YES/NO) WYE - DELTA (YES/NO) 2 SPEED, 1 WINDING (YES/NO) 2 SPEED, 2 WINDING (YES/NO) AREA CLASSIFICATION: CLASS_____ DIVISION _____ GROUP_____ TEMP CODE_____

** Conforms to NEMA MG-1, Part 31.*

SECTION 16251
AUTOMATIC TRANSFER SWITCH

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for Automatic Transfer Switch (ATS) system and controls.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI).
2. American Society of Civil Engineers (ASCE).
3. Institute of Electrical and Electronics Engineers (IEEE).
4. Insulated Cable Engineers Association (ICEA).
5. International Electrical Testing Agency (NETA).
6. International Society of Automation (ISA).
7. National Institute of Standards and Technology (NIST).
8. ASTM International (ASTM).
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA): 70, National Electric Code
11. UL.

1.03 SYSTEM DESCRIPTION

A. Supply an ATS as described below.

B. Sized to meet the load requirements.

1.04 SUBMITTALS

A. Furnish submittals in the areas described in the following:

1. Product Data:
   a. Weight of ATS.
   b. Dimensions:
      1) Height.
      2) Length.
      3) Width.
   c. Nameplate schedule.

d. Complete and Detailed Bills of Materials:
    1) A bill of material list, including quantity, description, manufacturer, part number, serial number, vendor name, with phone, and spare part list. Bills of material shall include all items within an enclosure.
    2) Provide the Bill of material in Microsoft Excel format.
e. Description of Operation:
    1) Transfer configuration, and operation.
    2) Protective functions.
f. List of recommended spare parts.
g. Repair Facility and Parts Stocking Agreement with the Factory:
    1) Outline in detail the manufacturer's parts stocking requirements and the method by which the manufacturer's representative verifies that the stock is at an acceptable level.
    2) Outline the method by which the manufacturer certifies the service personnel.
h. Emergency contact information.
i. Manufacturer's installation instructions.

B. Shop Drawings:

1. Layout drawings for all enclosures showing all components: Submit interior and exterior layout drawings.
2. Complete control schematic and wiring diagrams:

C. Installation Instructions:

1. Detail the complete installation of the enclosure, including moving and setting into place.
2. Provide anchorage sizing instructions and requirements for the enclosure.

D. Startup testing procedure.

E. Operation and Maintenance Manuals:

1. Submit fully detailed operating instructions:
    a. Describe all manual and automatic sequences.
    b. Provide instructions for selecting operating modes, changing operating modes, and performing manual operations.
2. Submit fully detailed maintenance manuals:
    a. Bill of material.
    b. Operating and maintenance instructions for all components.
    c. All Shop Drawings, updated to reflect as-built conditions.

3. Provide two bound copies of all manuals and a .pdf format electronic version of each.

F. Test Reports:

1. Certified report after the shop tests.
2. Written report after the startup from the manufacturer's startup representative:
   a. Report must state that the installation is complete and satisfactory, or list items requiring additional attention and a proposal for the actions.
   b. If any items require attention after the initial startup, a final report is required stating that the installation is complete and satisfactory.

G. Training documents.

1.05 QUALITY ASSURANCE

A. All control panels and devices shall be UL listed and labeled.

B. Package workmanship shall be neat and clean and have manufacturing QA approval documentation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping Precautions:

1. After completion of shop assembly and successful factory testing, enclose in polyethylene or secured sheeting to provide complete protection from damage, dust, and moisture.
2. Place dehumidifiers inside.

1.07 WARRANTY

A. Provide standard warranty for at least 2 years from date of acceptance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable automatic transfer switch manufacturers are:

1. ASCO.
2. Onan-Cummins.
3. Eaton.

2.02 EQUIPMENT

A. Automatic Transfer Switch:

1. The ATS shall be rated for 100A, 480V, three-phase, 60-Hz.
2. The ATS shall be provided that will integrate with and operate the standby generator. The ATS shall be UL rated under Standard 1008 for Transfer Switch Equipment. The switch shall be furnished in a UL rated NEMA 4 epoxy coated steel enclosure and shall be mounted on a service rack. The ATS shall be provided with a manual operating handle, shielded termination, and over-center type contact mechanisms to allow effective, manual operation.
3. The transfer switch shall be electrically operated and mechanically held. The switch shall be mechanically interlocked to ensure it remains in only one of two possible positions: Normal or Emergency. And at no time will the phase contacts both be closed simultaneously (Break-before-Make).
4. Transfer switch contacts include:
   a. Silver alloy construction.
   b. Neutral contact with the same ratings as the phase contacts, and will break last and make first operation.
5. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.
6. The switch shall be provided with a microprocessor-based control panel to direct operations. The control panel shall be provided with a keyed disconnect plug to enable the panel to be disconnected from the transfer switch for routine maintenance.
7. Voltage and Frequency Sensing:
   a. Voltage for each phase of the primary power source shall be monitored continuously, with pickup adjustable from 85 percent to 100 percent of nominal, and dropout adjustable from 75 percent to 98 percent.
   b. Single-phase voltage sensing of the emergency source shall be provided, with pickup voltage adjustable from 85 percent to 100 percent of nominal and independent frequency sensing with pickup adjustable from 90 percent to 100 percent.
   c. Accuracy shall be within plus or minus 2 percent.
   d. Voltage and frequency settings shall be field adjustable in 1 percent increments without the use of tools, meters, or power supplies.

8. Time Delays:
   a. The following time delays shall be provided, which shall be field adjustable without use of tools:
      1) Time Delay Start: Adjustable (0 second to 15 second) to prevent nuisance generator set starts in the event of momentary power system loss.
      2) Transfer Time Delay: Adjustable (2 seconds to 120 seconds) to allow generator set to stabilize before application of load.
      3) Retransfer Time Delay: adjustable (6 minutes to 30 minutes) to allow the power system to stabilize before retransfer of the load.
      4) STOP Delay: Adjustable (2 seconds to 10 minutes) to maintain availability of generator set for immediate reconnection in the event the normal source fails shortly after retransfer and to allow gradual generator set cool down by running unloaded.
9. A “Commit/No Commit to Transfer” selector switch shall be provided to select whether the load should be transferred to the backup source if the normal source restores before the generator is ready to accept the load.
10. Auxiliary SPDT contacts rated 10A at 250V ac shall be provided for the following conditions:
    a. Normal Source Available.
    b. Backup Source Available.
    c. Connected to Normal Source.
    d. Connected to Backup Source.
    e. ATS Fault.
11. Indicating lights shall be provided, one to indicate when the switch is connected to the normal source (green) and one to indicate when the switch is connected to the emergency source (red).
12. The switch manufacturer shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in production, design/development, installation, and servicing.
13. A minimum 100-hour battery backup power supply shall be provided to maintain clock settings during normal loss of power.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Test Procedures:

1. In accordance with UL 1008 and NETA.
2. Complete factory test to verify proper operation of all timers, settings, and operation.

B. Furnish the services of a factory certified technician during the startup and adjustment period to ensure that all items furnished are in proper operating condition:

1. Technician must be completely knowledgeable in the operation, maintenance, and startup of the transfer switch system.

C. Results of the testing shall be reviewed by the Owner. If the test results are not acceptable to the Owner, actions to remedy the unacceptable conditions will be required. These actions may include installation of additional equipment, modification of existing equipment, or changes in operating practices.

D. Furnish a written report after startup signed by the manufacturer's authorized representative:

1. Report shall state that the installation is complete and meets all of the manufacturer's requirements.
2. List any items requiring additional attention.

E. Correct defects that become evident during testing.

F. Test all control functions in conjunction with the ATS startup:

1. These tests shall include all normal switching functions and delays.
2. Proper operation of the exercising feature.
3. Confirm all control input and output signals.

G. Upon completion of the work, at a time to be designated by the Owner's representative, manufacturer shall provide training for the Owner on the operation of the ATS.

END OF SECTION

SECTION 16262
VARIABLE FREQUENCY DRIVES 0.50 – 50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Variable frequency drives (VFD) 0.5 hp to 50 hp for control of NEMA Design B squirrel cage induction motors installed in:
   a. Standalone enclosures.
   b. Motor control centers (MCCs).
   c. Vendor furnished equipment.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. Institute of Electrical and Electronics Engineers (IEEE): 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
3. International Organization for Standardization (ISO): 9001 - Quality Management Systems - Requirements.
4. UL: 508C, Power Conversion Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Point of Common Coupling: The point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected panelboard or motor control center bus supplying power to the VFD.
2. VFD System is defined as follows:
   a. VFD in a standalone enclosure.
   b. VFD installed in a motor control center.
   c. VFD as a component in vendor-furnished equipment.[ADD. 3]

1.04 SYSTEM DESCRIPTION

A. ~~Design Requirements: Each VFD system consists of all components required to meet the performance, protection, safety, testing, and certification criteria of this section.~~Design requirements: Each VFD system consists of all components required to meet the performance, protection, safety, testing, on-site startup with all required documentation, and certification criteria of this Section.[ADD. 3]

B. ~~The final VFD size shall be based on the full load current of the approved submittals of the driven load.~~The final VFD size shall be based on the full load current of the approved submittals of the driven load.

~~1. The VFD System:~~
~~a. Is a fully integrated package.~~
~~b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.~~
1. The VFD system:
   a. Fully integrated package.
   b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.[ADD. 3]

C. ~~Any modifications to a standard product necessary to meet this section shall be made only by the VFD manufacturer:~~Any modifications to a standard product necessary to meet this Section shall be made by the following entities:

~~1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.~~

~~2. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:~~

~~a. Provide equipment necessary to mitigate potential damage to motor insulation.~~

1. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer, panel builder or system integrator to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
   a. Provide equipment necessary to mitigate potential damage to motor insulation.
2. VFD installed in a motor control center:
   a. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the MCC manufacturer to ensure a properly coordinated, fully integrated drive system.
3. VFD installed in a standalone enclosure:
   a. Each VFD will be installed in a dedicated standalone enclosure that is sized to allow for cooling and spatial considerations. The panel builder or integrator will provide a standalone unit that is completely wired, assembled, and tested as a complete system. The variable frequency drive will be one from the list of manufacturers in this specification, including all supporting components.
4. VFD installed in vendor-furnished equipment.
   a. Vendor furnished equipment will include a variable frequency drive from the list of manufacturers in this specification. Vendor furnished equipment shall be completely wired, assembled, and tested as a complete system.[ADD. 3]

D. Performance:

1. Operating Envelope:
   a. Speed and Torque Requirements:
      1) Provide a constant torque VFD regardless of the driven load.
      2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 percent to 200 percent (25-Hz to 120-Hz) speed range.

b. Current Requirements:
   1) Full rated current output on a continuous basis.
   2) Constant Torque VFD:
      a) Minimum 150 percent current overload for 1 minute.
      b) Minimum continuous rating of 1.16 percent of motor nameplate full load current.

2. Minimum VFD System Efficiency:
   a. 96 percent.
   b. VFD system efficiency shall be calculated as follows:

      Efficiency (%) = [Power (Load) / Power (Supply)] x 100

3. Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
4. Total Power Factor:
   a. Minimum of 0.96 lagging across the entire speed range.
   b. At no speed shall the VFD have a leading power factor.
5. Frequency Accuracy: Minimum of within 0.01 percent.
6. Speed Regulation: Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical:

   1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

B. Product Data:

   1. Manufacturer of the VFD.
   2. Manufacturer of all components of the VFD.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
   4. Nameplate Schedule: Provide in accordance with Section 16075, Electrical Identification.

5. Bill of material, including quantity, description, manufacturer, part number, serial number, vendor name with phone, and spare part list with unit price. Bills of material shall include all items within enclosure.
   a. Provide the Bill of material on a USB Flash drive in Microsoft Excel format.
6. Ratings:
   a. Voltage.
   b. Phase.
   c. Input current.
   d. Output current.
   e. Interrupting rating.
   f. Momentary current rating.
7. List of recommended spare parts.
8. Catalog cut sheets for major components.
9. Design Data:
   a. Efficiency and power factor values.
   b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
   c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
   d. Certification that all electronic circuits and printed circuit boards shall be conformally coated.
10. List of diagnostic indicators.
11. List of fault and failure conditions that the drive can recognize and indicate for simultaneous occurrence.
12. List of standard features and options.
13. For equipment installed within a motor control center, the contractor shall submit a letter confirming each VFD unit contained within the MCC has been coordinated with its respective driven load. Letter shall list VFD location and driven equipment tag numbers as well as the FLA rating of each driven load motor. Motor data sheets for each driven load motor shall be attached to the coordination letter for verification.
14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050, Common Work Results for Electrical:
   a. Manufacturer’s statement of seismic qualification with substantiating test data.

b. Manufacturer's special seismic certification with substantiating test data.
   1) List of parameters that will be changed from default settings.

C. Shop Drawings:

1. Complete plan and elevation drawings showing:
   a. All dimensions.
   b. Panel, sub-panel and component layout indexed to the bill of material.
   c. Conduit connections.
2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
   a. Include terminal number and wire numbers.
4. Complete single-line and three-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
   a. Clearing indicate device electrical ratings on the Drawings.

D. Installation Instructions:

1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
   a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
   a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050, Common Work Results for Electrical.
   b. Submit anchoring drawings with supporting calculations.
   c. Drawings and calculations shall be stamped by a professional engineer registered in the state of Oregon.

E. Operation and Maintenance Manuals:

1. Startup and commissioning instructions and data.
2. Operating Manuals: Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
3. Operating Instructions: Written descriptions detailing the operational functions of all controls on the front panel.
4. Maintenance Manual:
   a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
   b. Manuals shall include, but are not limited to the following:
      1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
      2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.
      3) All Schematic Wiring and External Diagrams: Furnish drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.
5. List of parameters that have been changed from default settings.

F. Test reports.

G. Manufacturer's Field Reports:

1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

H. Record Documents: Certified Record Documents of equipment with information listed above.

1.06 SEISMIC DESIGN REQUIREMENTS

A. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads.

1.07 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Qualifications:

1. Any third-party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
2. VFD systems shall be UL 508C listed and labeled.
3. Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.08 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical, and Section 01756, Testing and Facility Startup.

B. Ship the VFDs and associated equipment to the Job Site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment:

1. VFDs shall be delivered to the Site preassembled and wired.
2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 01756, Testing and Facility Startup.

1.10 SEQUENCING

A. Refer to Section 01756, Testing and Facility Startup.

B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit certified test results for Engineer’s review.

1.11 SCHEDULING

A. As specified in Section 01756, Testing and Facility Startup.

1.12 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

B. Supplier shall coordinate warranties for pumps, motors, and drives such that supplier acts as a single point of contact for all warranties.

C. Owner shall be listed as recipient of all warranties.

D. At no additional charge the Manufacturer shall replace any work or material they have provided which develops defects within 2 years from date of final acceptance of installed equipment by Owner.

1. Manufacturer's service and repair support during and after warranty.
2. Correction of Defective Work: During the warranty period, Supplier shall respond to telephone notification of defective work or equipment malfunction from the Owner by dispatching a competent authorized representative to the Project Site within 24 hours. Supplier's representative shall have access to all necessary parties (if necessary) within 24 hours following notification of defective work or equipment malfunction. Repairs and adjustments involving parts shall start within 48 hours of said notification.

E. All materials and equipment shall be warranted against defective materials, design and workmanship.

F. During the warranty period, the Manufacturer or his authorized dealer is required to make the necessary repairs or replacements onsite.

G. Warranties which mention that the part must be returned to the factory are not acceptable.

H. During the warranty period, the Owner will not accept charges for:

1. Travel time.
2. Mileage.
3. Materials.
4. Onsite repair labor.

I. Warranty shall list any and all items excluded.

J. If necessary, as determined by the Owner, any repairs must be made on a premium time basis.

1.13 SYSTEM START-UP AND COMMISSIONING

A. As specified in Section 01756, Testing and Facility Startup.

B. The VFD manufacturer shall be responsible for startup of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Eaton.
2. Allen-Bradley.
3. Siemens.
4. ABB.
5. “Or-equal.”

2.02 EQUIPMENT

A. General:

1. Sinusoidal pulse width modulated (PWM) type drive.
   a. Six-pulse insulated gate bipolar transistor (IGBT) power section.
   b. Microprocessor based controls.
   c. 5 percent line reactors and 3 percent dv/dt load filters.

B. Ratings:

1. Voltage:
   a. Input Voltage: 480 volts within 10 percent, three-phase, 60 Hz.

C. Operational Features:

1. Protective Features:
   a. Provide the following minimum protective features:
      1) Motor overload protection.
      2) Instantaneous overcurrent.
      3) Instantaneous overvoltage.
      4) Undervoltage.
      5) Power unit overtemperature.
      6) Phase loss.
      7) VFD output short circuit.

2. Control Mode:
   a. Operation in either a constant volts/hertz or sensorless vector mode.
   b. The control mode selectable using the programming keypad.
   c. With VFD running in “REMOTE” mode, moving the selector switch to “LOCAL” mode drive should stop.
3. Frequency Control:
   a. Minimum of three selectable skip frequencies with adjustable bandwidths.
   b. Programmable minimum frequency.
   c. Programmable maximum frequency.
4. Acceleration/Deceleration:
   a. Separately Adjustable Acceleration and Deceleration Rates: Each rate adjustable from 0.01 seconds to 3,600 seconds.
   b. Spinning Load: The VFD shall be capable of determining the speed and direction of a spinning load, “catch” the load and accelerate or decelerate it without damage to the load.
5. Programmable Loss of Signal:
   a. Upon loss of speed reference, the VFD shall be programmable to either:
      1) Stop.
      2) Maintain current speed.
      3) Default to pre-selected speed.
6. Power Interrupt Ride-through: The VFD shall be capable of continuous operation in the event of a power loss of five cycles or less.
7. Inputs/Outputs:
   a. Manufacturer’s standard number the following:
      1) Analog Inputs: Configurable as either 0 volts to 10 volts or 4 milliamperes to 20 milliamperes.
      2) Analog Outputs: Programmable 4 milliamperes to 20 milliamperes isolated.
8. Discrete Inputs: Programmable.
   a. Discrete Outputs:
      1) Programmable.
      2) Form C relay contacts.
9. Potentiometer Three-wire Input: Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
10. Communications:
    a. Provide each VFD with an EthernetIP communications interface module for communicating with an Allen-Bradley control system.
    b. Stop on a communication loss to PLC.

11. Diagnostics:
    a. Store a minimum of four fault conditions in non-volatile memory on a first in- first out basis.
    b. Operational Parameters Stored at the Time of the Fault:
        1) Operating frequency.
        2) Drive status.
        3) Power mode.
    c. Fault memory accessible via RS-232, RS-422, or RS-485.
12. Automatic Restart:
    a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to nine restart attempts.
        2) Adjustable time delay between restart attempts.

2.03 COMPONENTS

A. The VFD shall be capable of being programmed while energized. Provide an accessible port to connect a laptop from outside of the enclosure with the enclosure door closed and the VFD energized.

B. Provide cabinet cooling devices required to maintain the VFD within the Manufacturer's specified temperature limits for the project conditions.

1. Controlled by control power on.
2. Long-life low noise cooling fans, sized for 150 percent capacity cooling.
3. Provide power and fuse protection for the cooling fans.

C. Provide internal cooling devices and controls required to maintain the VFD within the Manufacturer's specified temperature limits for the project conditions.

1. Fans shall start/stop with the VFD internal thermostat.

D. Power Disconnect:

1. Flange mounted thermal magnetic circuit breaker.
2. Lockable in the OFF position.

E. Line Reactors: 5 percent input.

F. Load Filters: 3 percent dv-dt.

2.04 ENCLOSURES

A. VFDs shall be installed within motor control centers where shown on the Drawings. VFDs not installed within MCCs shall be installed in enclosures as specified in Section 16050, Common Work Results for Electrical, Paragraph Plant Area Electrical Work Requirement.

B. Provide louvers on the VFD enclosure, adequate in size and quantity to cool the VFD. No filters are required.

C. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions. The cooling fans shall run continuously with VFD control power.

D. All wiring shall be MTW-type.

E. Control Power Transformer:

1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
2. With primary and secondary fusing.
3. Sized to power all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

F. Door mounted speed potentiometer for manual speed control.

G. Keypad:

1. Provide each VFD with a keypad for programming only.
   a. Control shall be through pilot devices.
2. Keypad Requirements:
   a. Password security to protect drive parameters.
   b. Mounted on the door of the motor control center.
   c. Back-lit LCD: Minimum of two lines with a minimum of 16 characters per line.
   d. Programming and Display Features Language: English.
   e. Capable of displaying the following parameters:
      1) Speed (percent).
      2) Output current (amperes).
      3) Output frequency (hertz).
      4) Input voltage.
      5) Output voltage.
      6) Total three-phase kilowatt.
      7) Kilowatt-hour meter.

8) Elapsed run time meter.
9) Revolutions per minute.
10) Direct current bus voltage.

3. In addition to all keys required for programming, provide the following controls on the keypad:
   a. Auto/manual selector.
   b. Start pushbutton.
   c. Stop pushbutton.
   d. Jog pushbutton.
   e. Speed increment.
   f. Speed decrement.
   g. Forward/reverse selector.
   h. Run LED indicator.
   i. Program LED indicator.
   j. Fault LED indicator.
4. Provide the VFD with the hardwired controls as indicated on the Drawings.
5. The keypad shall be installed on the VFD enclosure door. The keypad shall be accessible.

H. Provide pilot devices, including but not limited to, selector switches, pushbuttons, and indicator lights, as shown on the Drawings.

1. 22 millimeter, IEC.
2. Each door mounted device shall be labeled on the front and back. Refer to the CWS Equipment Tag Numbering Standards for additional information.

I. General Purpose Ice Cube Relays: Locking Pushbutton, LED, Test Button. For testing and troubleshooting.

J. All conductors shall be individually labeled using heat shrinkable tube labels. Each label shall be typewritten.

K. Conductor color coding shall be as follows:

1. Grounded Conductors: White.
2. Grounding Conductors: Green.
3. Ungrounded Conductors: Red.

L. Power conductor (480V) color coding shall be as follows:

1. Phase A: Brown.
2. Phase B: Orange.
3. Phase C: Yellow.

M. Provide one common grounding bus bar for all grounding connections. The use of multiple grounding bus bars shall not be permitted. The grounding bus bar shall be sized for all grounding connections entering and leaving the enclosure.

2.05 ACCESSORIES

A. Metal Oxide Varistors:

1. Provide protection for the VFD against:
   a. Line Transients: 5,000 volt peak minimum.
   b. Line to Ground Transients: 7,000 peak minimum.

B. Conformal Coating: Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H2S and chlorine.

2.06 FINISHES

A. Enclosure finish shall be manufacturer’s standard gray.

2.07 SOURCE QUALITY CONTROL

A. VFDs and Enclosures, Factory Testing:

1. Control Strategies described in Section 17101, Control Loop Descriptions, shall be reviewed and understood by supplier prior to commencement of the Factory Test.
2. Provide a certified copy of the test results to the Owner:
   a. Include in the results any minor adjustments made during the test.
   b. If major changes must be made, the test must be repeated.
3. General:
   a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
   b. All VFDs furnished under this section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.

c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.

4. Failure of any component during testing requires repair of the faulted component and complete retest.
5. Testing Sequence:
   a. Submit a detailed test procedure for the VFD factory test:
      1) A minimum of 8 weeks in advance of the proposed testing date.
      2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
6. Component Tests:
   a. Preliminary Inspection:
      1) Verify that all components are correct.
      2) Verify that all connections are properly torqued.
   b. Printed Circuit Boards:
      1) Test for correct component placement and value and complete board functional test to ensure proper performance with specified tolerances.
      2) Heat cycle test for 48 hours at 60 degrees C.
      3) Apply control power to microprocessors, printed circuit boards, diagnostic boards, and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.
      4) Test operation of all analog and discrete inputs and outputs.
   c. Wiring:
      1) Control and power wiring continuity verified point-to-point.
      2) Hi-pot power and control wiring at manufacturer's recommended levels.
      3) Verify ground bond resistance.
   d. Load Testing:
      1) No load testing in accordance with the manufacturer's standard factory test procedure.
      2) Full Load Testing:
         a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.

b) Load test each VFD at a minimum ambient temperature of 40 degrees C.
   (1) Monitor and record temperature rise.
   (2) Once temperature rise stops, continue to operate the VFD for a minimum of 2 hours.
      (a) If operating temperature exceeds the rated value, repair or replace the VFD and retest.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

C. General:

1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, terminal block lugs to land motor leads to, wires between VFD and terminal block lugs and other accessories needed to complete the installation of the VFD (free-standing or within motor control center).
2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
3. Perform work in accordance with manufacturer's instructions and Shop Drawings.
4. Furnish components and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install free-standing enclosures on 3-1/2-inch raised concrete housekeeping pad:
   a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
   b. Weld and/or bolt the VFD frame to the leveling channels.

7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
   a. Improperly cut holes will require that the entire panel be replaced. No hole closers or patches will be allowed.
   b. All conduits shall use threaded hubs for connections to enclosures.
8. Bundle circuits together and terminate in each unit:
   a. Tie with nylon wire ties.
   b. Label all wires at each end with wire numbers shown on the approved control drawings.
   c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks and wire ferrules.
9. Field wiring shall be installed so that it doesn't block access to internal control panel relays and devices. The relays and devices shall be accessible for testing, maintenance, inspection, troubleshooting and replacement. The Owner shall determine if the relays and devices are accessible, and the Contractor shall move or relocate field wiring as directed by the Owner.
10. Maintain separation of all power, signal, and control wiring within the VFD enclosure. Verify the routing of all wiring within the VFD enclosure with the Owner prior to installation. Move or relocate the field wiring as directed by the Owner to maintain separation.
11. All grounding conductors shall be insulated.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Provide the services of a VFD manufacturer representative for startup assistance and training:

1. Inspection and Field Adjustment: Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
2. Startup Field Testing:
   a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
   b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
   c. Test Power loss to verify VFD returns to status before power loss at 3 seconds and also complete power loss to VFD, screen dark.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

1. All adjustments shall be recorded and electronic PDF provided to Owner. Leave program in VFD and keypad.

B. Provide the services of a VFD manufacturer factory technician to make all drive parameters and protective device settings:

1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
2. Provide documentation of VFD settings included but not limited to:
   a. Minimum speed.
   b. Maximum speed.
   c. Skip speeds.
   d. Current limit.
   e. Acceleration time.
   f. Deceleration time.
   g. Parameter list indicating changes from factory default settings.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. The authorized representative shall instruct the Owner's personnel in the operation and maintenance of the equipment, including step by step troubleshooting with test equipment for 8 hours, with the first half day in classroom setting and the rest with actual equipment furnished. Instructions shall be specific to the VFD models provided in this Project.

C. Training shall be scheduled a minimum of 4 weeks in advance of the first session. Training dates and time shall be determined by the Owner. Training shall include individual sessions for up to ten personnel.

1. Proposed training materials shall be submitted for review a minimum of 4 weeks in advance, and comments shall be incorporated prior to training. Training materials shall remain with the trainees. The Owner may video-record the training for later use with the Owner's personnel.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16411
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Fusible and nonfusible disconnect switches.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. National Electric Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment.
   b. KS 1-2001, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
3. UL:
   a. 20, General-Use Snap Switches.
   b. 98, Enclosed and Dead-Front Switches.
   c. 508, Standard for Industrial Control Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions: Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.

B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

C. Provide a local horsepower rated disconnect switch as indicated on the Drawings.

D. Provide Auxiliary Contact for VFD applications to disable VFD control power when the disconnect is open.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer.
2. Manufacturer’s specifications and description.
3. Ratings:
    a. Voltage.
    b. Current.
    c. Horsepower.
    d. Short circuit rating.
4. Fused or nonfused.
5. NEMA enclosure type.
6. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
7. Weight.
8. Dimensioned drawings.
9. Elementary diagrams.
10. Wiring diagrams.
11. Nameplate list.
12. Evidence that the equipment will be provided with all specified accessories, options, features, and characteristics.
13. Certifications that the equipment is designed and manufactured in conformance with applicable codes and standards.

C. Manual. Provide manufacturer’s installation and maintenance instruction manuals in conformance with Section 16050, Common Work Results for Electrical.

D. Shop Drawings:

1. Manufacturer’s installation instructions:
   a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
   b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
2. Identify motor or equipment served by each switch; indicate nameplate inscription.

E. Installation Instructions:

1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical, and calculations:
   a. Stamped by a professional engineer registered in the State of Oregon.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. NEMA KS1, Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
2. UL 98, Enclosed and Dead-Front Switches.

C. Disconnect switches shall be UL listed and labeled.

1.07 SEISMIC REQUIREMENTS

A. Provide electrical equipment with construction anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.

1.08 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Disconnect Switch:

1. Switch Mechanism:
   a. Quick-make, quick-break heavy-duty operating mechanisms:
      1) Provisions for padlocking the switch in the OFF position.
      2) A minimum of 90-degree handle travel position between OFF and ON positions:
         a) Provide handle position indicators to identify the handle position.
      3) Full cover interlock to prevent opening of the switch door in the ON position and to prevent closing the switch mechanism with the door open:
         a) With an externally operated override.
2. Switch Interior:
   a. Switch blades visible when the switch is OFF and the cover is closed, window switch.
   b. Lugs:
      1) Front accessible.
      2) Removable.
      3) UL listed for 60 degrees C or 75 degrees C copper conductors.
   c. Current carrying parts completely plated to resist corrosion.
   d. Removable arc suppressors to facilitate easy access to line side lugs.
   e. Furnish equipment ground kits for every switch.
   f. Installed Auxiliary contact kit.
3. Ratings:
   a. UL horsepower rated for AC or DC with the rating not less than the load served.
   b. Current: 30 amperes to 1,200 amperes.
   c. Voltage:
      1) 250V ac, dc.
      2) 600 volts (30A to 200A, 600V dc).
   d. Poles: Two, three, four, and six poles.

e. UL Listed Short Circuit Ratings:
1) 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30 amperes to 600 amperes).
2) 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30 amperes to 600 amperes employing appropriate fuse rejection).
3) 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800 amperes to 1,200 amperes).
f. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050, Common Work Results for Electrical, for the installed location.

4. Size, fusing and number poles as indicated on the Drawings or as required.
5. Local power disconnects for 480V electrical actuators shall be three-pole, 600V, nonfusible, NEMA 4X stainless steel, 16 UL amps. Power disconnect shall be ABB EOT16U3S4-P, “or-equal.”
6. For Class 1 Division 1 areas provide an explosion proof disconnect switch rated for use in Class 1 Division 1 areas.
7. Auxiliary Contacts: Two sets of Form C contacts shall be provided for all disconnect switches. 24V, 50 mA rated.
8. Provide with upper knife switch viewing window.

B. Motor Rated Toggle Switches:

1. Switch Mechanism:
a. Rotary Style Operating Mechanism:
1) Provisions for padlocking the switch in the OFF position.
2) A minimum of 90-degree handle travel position between OFF and ON positions:
a) Provide handle position indicators to identify the handle position.
b) Cover shall be Leviton COVER-2.

C. Non-Automatic Transfer Switch:

1. General: The non-automatic transfer switch shall transfer from the normal service to an alternate service. The transfer shall not take place automatically but shall be initiated manually by operating personnel. Transfer back to the normal power supply shall also be initiated manually. The switch shall be UL listed and shall bear the UL label.
2. Construction:
a. The non-automatic transfer switch shall be of the mechanically held double throw type and connected to the transfer mechanism by a simple over-center linkage. All main power contacts and

auxiliary contacts shall be mechanically attached to a common shaft, shall be double-break silver alloy with wiping action, and shall be protected by arcing contacts. Arcing contacts shall close before and open after the main contacts and shall be readily replaceable. Contact design and arrangement shall permit repeated making and breaking of full-load current, in a combination of motor and other loads, without damage to the main contacts. Provide a main transfer mechanism utilizing rugged metal parts throughout. Molded circuit breaker type designs are not acceptable.

b. The enclosure shall be NEMA 12 construction with hinged doors on the front for access to the interior controls. Secure doors by a locking type latch. Provide two keys for the lock.

c. Cable connections shall be accessible from the front without removing internal components.

d. Safety Requirements:
   1) Arrange the electrical supply to each control panel to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits. Cover any live parts within the control panel fed from foreign control or signal circuits or arrange for them to be disconnected by one of the following methods:
      a) Door-operated enclosed disconnect switches; or
      b) Clearly identified enclosed manually operated disconnect switches, which may be located inside the control panel door, provided the operating handles are isolated or barriered from all open live parts.
   2) Arrange the controls so that manipulation of control switches, adjustments to timing relays, or replacement of fuses can be done without exposure to live parts.

e. The transfer switch shall have the following features:
   1) Continuous rating of 480 volts, three-phase, with three poles and full neutral bus. Current rating shall be as shown on the Drawings.
   2) Adequate line and load lugs for terminating the power conductors shown on the Drawings.
   3) A terminal strip with terminals for terminating all external control circuits. Number all terminals using the wire number for the wire terminated.
   4) Cable wiring with cable ties, secured in place and guarded where subject to mechanical injury.
   5) Permanent identification of each wire at each point of connection using numbered wiring sleeves. Provide electrically common wires with the same number. Uniquely number electrically different wires.

f. UL Label: The transfer switch shall have a UL label on the unit when it arrives at the Site. Absence of the UL label shall be sufficient cause for the unit to be rejected. Provide all the specified features, options, and accessories. If the manufacturer's standard UL unit does not have the specified features, options, or accessories, then provide alternative features, options, or accessories to accomplish the same purpose in a manner similar to that specified, while still providing a unit with a UL label.

g. Current Ratings:

1) The transfer switch shall have continuous ampere rating as shown on the Drawings and a short circuit withstand rating for three cycles at 480 volts as follows:

Continuous Ampere Rating	**Withstand RMS Amperes, Symmetrical**
100 A	65,000

h. Finish: Shall be manufacturer’s standard not less than 3 mils thick. Color shall be light gray ANSI 61 per Z55.1.

i. Factory Tests: Assemble, wire and test the transfer switch at the factory. Conduct test to assure that every component functions properly. Submit prototype test reports on bus bracing for the Engineer’s review.

2.02 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated neutral kit as indicated on the Drawings.

C. NEMA Type 7 and Type 9 enclosures furnished with drain and breather kit when used in outdoor applications.

2.03 MANUFACTURERS:

A. One of the following:

1. Eaton.
2. Siemens.
3. Appleton.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Locations of disconnect switches on the Drawings are schematic in nature only. Contractor shall install disconnects in a readily accessible location, as defined by the NEC. All NEC working clearances shall be maintained. The Contractor shall verify the location of all power connections for equipment requiring disconnects with the approved Submittals and install the disconnect to meet Code.

1. Install a disconnect for every motor even if not indicated on the Drawings.

C. Install motor rated toggle switches at gate and valve actuators.

D. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

E. General:

1. Use Myers hubs for all conduit penetrations.
2. Conduits shall not enter the top of boxes in wet locations or in locations where subject to water.
3. Provide all mounting brackets, stands, supports and hardware as required:
    a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
    b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
4. When possible, mount switches rigidly to exposed building structure or equipment structural members:
    a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8-inch air space between the enclosure and supporting surface.
    b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
5. Provide a nameplate for each disconnect switch:
    a. Provide per requirements specified in Section 16075, Electrical Identification.

b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

6. Install with minimum 10 inches of clearance to operate external override.
   a. Install on the right side of an LCS.

3.02 COMMISSIONING

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16422
MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Motor starters and contactors.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 01756, Testing and Facility Startup.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16070, Hangers and Supports.
   e. Section 16075, Electrical Identification.
   f. Section 16123, 600-Volt or Less Wires and Cables.
   g. Section 16444, Low-Voltage Motor Control Centers.
   h. Section 17710, Control Systems Panels, Enclosures, and Panel Components.

1.02 REFERENCES

A. As specified in Section 16050, Common Work Results for Electrical.

B. International Electrotechnical Commission (IEC):

1. 60 947-4, Low-Voltage Switchgear and Control Gear.
2. 801-1, Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, Part 1: General Information.

C. National Electrical Manufacturer's Association (NEMA): ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.

D. UL:

1. 508, Standard for Industrial Control Equipment.
2. 508A, Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

B. Specific Definitions and Abbreviations:

1. FVNR: Full voltage non-reversing.
2. Overload Relay Class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

A. General Requirements: Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical:

1. Submit motor starter data with equipment submittal.

B. Product Data:

1. Manufacturer.
2. Catalog cut sheets.
3. Technical information.
4. Complete nameplate schedule.
5. Complete bill of material.
6. List of recommended spare parts.
7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
8. Electrical Ratings:
   a. Phase.
   b. Wire.

c. Voltage.
d. Ampacity.
e. Horsepower.

C. Shop Drawings:

1. Elementary and Schematic Diagrams:
   a. Provide one diagram for every starter and contactor.
   b. Indicate wire numbers for all control wires on the diagrams: Wire numbering as specified in Section 16075, Electrical Identification.
   c. Indicate interfaces with other equipment on the Drawings.

D. Installation Instructions:

1. For equipment installed in structures designated as seismic design category A or B:
   a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.
2. For equipment installed in structures designated as seismic design category C, D, E, or F:
   a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050,Common Work Results for Electrical.
   b. Submit anchoring drawings with supporting calculations.
   c. Drawings and calculations shall be stamped by a professional engineer registered in the state of Oregon.

E. Operation and Maintenance Manuals:

1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this section. Including but not limited to:
   a. Electrical Ratings:
      1) Phase.
      2) Wire.
      3) Voltage.
      4) Ampacity.
   b. Complete bill of material.
   c. Manufacturer’s operating and maintenance instructions starter and/or contactor component parts, including:
      1) Protective devices (fuses, breakers, overload relays, and heater elements).
      2) Pilot devices.
   d. Complete renewal parts list.

e. As-built Drawings:
   1) Furnish as-built drawings for each starter and contactor indicating final:
      a) Wire numbers.
      b) Interfaces with other equipment.
   2) 11-inch by 17-inch format.

F. Certifications: Provide manufacturer's certification that all electronic circuits and printed circuit boards are conformally coated.

1.06 SPARE PARTS

A. No spare parts are required.

1.07 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Regulatory Requirements:

1. All starters and components shall be UL listed and labeled:
   a. UL 508, Industrial Control Equipment.
   b. UL 508A, Industrial Control Panels.
2. NEMA ICS 2, Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
3. Combination starters shall be UL listed and labeled.

1.08 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.11 SYSTEM START-UP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. NEMA Starters and Contactors:
   a. Eaton.
   b. Allen-Bradley.
   c. Siemens.
   d. “Or-equal.”

2.02 MANUFACTURED UNITS

A. General:

1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
2. NEMA Size, Design, and Rated: NEMA Size 1 minimum.
3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor: If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Full Voltage Starters (FVNR):

1. Across-the-line full voltage magnetic starters.
2. Rated for 600 volts.
3. Electrical characteristics as indicated on the Drawings.
4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
5. All starters shall be furnished with thermal overload relays.
6. Double-break silver alloy contacts.
7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.

2.03 COMPONENTS

A. Molded Case Circuit Breakers: Circuit breaker type and ratings as indicated on the Drawings.

B. Transient Voltage Surge Suppression: Furnish transient voltage surge protection across the coil of each starter, contactor, and relay.

C. Conformal Coating: Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H2S and Chlorine.

D. Contactors:

1. NEMA size as indicated on the Drawings.
2. Electrically Held: For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
3. Factory adjusted and chatter free.
4. Auxiliary Contacts:
    a. Contact Ratings as Per NEMA A 600 Rating: Auxiliary contacts rated 10 amps at 600 volts.
    b. Provide all contacts indicated on the Drawings, and any additional contacts required for proper operation.
    c. Provide at least one normally open and one normally closed spare auxiliary contact.
5. Constructed in accordance with the following standards:
    a. UL 508.
    b. IEC 947-4.
        1) Type 1 coordination when protected by a circuit breaker.
        2) Type 2 coordination when protected by a suitable UL listed fuse.
    c. IEC 801-1 Part 2 through Part 6.

E. Overloads:

1. Thermal:
    a. Interchangeable heater packs.
    b. Ambient Insensitive:
        1) Operating Temperature: Minus 20 degrees C to 70 degrees C.
    c. Thermal memory.
    d. Protective Functions:
        1) Motor overcurrent.
        2) Phase unbalance (adjustable.)
        3) Phase loss.
        4) Ground fault protection (where required).

e. Self-powered.
f. Visible trip indicator.
g. Push-to-trip test.
h. Isolated normally open alarm contact.
i. Normally closed trip contact.
j. Manual reset.

F. Control Power Transformer:

1. Furnish integral control power transformer capacity to power:
   a. All motor controls indicated on the Drawings.
   b. Motor winding heaters, through a normally closed auxiliary contact on the starter. Approximate motor space heater rating shall be 250 W.
2. Primary and secondary fusing as indicated on the Drawings: Fusing sized by the manufacturer for the rating of the transformer furnished.
3. Control Power Transformer Secondary Voltage: 120V ac.

G. Provide pilot devices, including but not limited to, selector switches, pushbuttons, and indicator lights, as shown on the Drawings.

1. 22 millimeters, IEC.
2. Each pilot device shall be labeled on the front and back. Refer to the CWS Equipment Tag Numbering Standards for additional information.

H. All conductors shall be individually labeled using heat shrinkable tube labels. Each label shall be typewritten.

I. Conductor color coding shall be as follows:

1. Grounded Conductors: White.
2. Grounding Conductors: Green.
3. Ungrounded Conductors: Red.

2.04 ACCESSORIES

A. Lugs and Terminals:

1. For all external connections of 6 AWG and larger.
2. UL listed for either copper conductors.

B. Surge Protective Devices: Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot Devices:

1. Provide pilot lights, switches, selector switches, pushbuttons, and other devices as specified or as indicated on the Drawings.
2. As specified in Section 17710, Control Systems Panels, Enclosures, and Panel Components.

D. General Purpose Ice Cube Relays: Locking Pushbutton, LED, Flag Indicator for testing and troubleshooting.

E. Nameplates and Wire Markers: As specified in Section 16075, Electrical Identification.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project Site.

C. All conduits shall use threaded hubs for connections to enclosures.

D. Field wiring shall be installed so that it doesn't block access to internal control panel relays and devices. The relays and devices shall be accessible for testing, maintenance, inspection, troubleshooting and replacement. The Owner shall determine if the relays and devices are accessible and the Contractor shall move or relocate field wiring as directed by the Owner.

E. Maintain separation of all power, signal, and control wiring within the VFD enclosure. Verify the routing of all wiring within the VFD enclosure with the Owner prior to installation. Move or relocate the field wiring as directed by the Owner to maintain separation.

F. Starters in Motor Control Centers: Install as specified in Section 16444, Low-Voltage Motor Control Centers.

G. Starters in Control Panels: Install as specified in Section 17710, Control Systems Panels, Enclosures, and Panel Components.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Demonstrate operation of equipment as specified in Section 16950, Field Electrical Acceptance Tests: Demonstrate the operation of every motor starter to the Engineer’s and Owner’s satisfaction.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16442
PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. Lighting and Appliance Branch Circuit panelboards.
2. Power Distribution Panelboards.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 10400, Signage.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16075, Electrical Identification.
   e. Section 16444, Low-Voltage Motor Control Centers.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.
   c. Space for future protective devices.
   d. Voltage, frequency, and phase ratings.
   e. Enclosure type.
   f. Bus and terminal bar configurations and current ratings.

g. Provisions for circuit terminations with wire range.
h. Short circuit current rating of assembled panelboard at system voltage.
i. Features, characteristics, ratings, and factory settings of auxiliary components.
j. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01612, Anchorage and Bracing.

4. List of manufacturer's recommended spare parts.

B. Informational Submittals: As required by Section 01612, Anchorage and Bracing.

1.03 SPARE PARTS

A. No spare parts are required.

1.04 SEISMIC REQUIREMENTS

A. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.

1.05 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton.
2. Siemens.
3. Square D Co.
4. "Or-equal."

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 16444, Low-Voltage Motor Control Centers.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600 volts or less in accordance with this section.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by the NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous,” “100 percent,” etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the SCCR indicated on the Drawings.

F. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
   a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
   b. Spaces: Cover openings with easily removable cover.
3. Series-Connected Short Circuit Ratings: Devices shall be fully rated; series-connected ratings unacceptable.

G. Circuit Breakers:

1. General:
   a. Thermal-magnetic unless otherwise indicated.
   b. Molded case.
   c. Trip indicating handle showing ON/OFF and TRIPPED positions.
   d. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
   e. Mechanically trip free from the handle.
   f. Lockable in the OFF position.
2. Noninterchangeable: In accordance with NEC.

3. Bus Connection: Bolt-on circuit breakers in 480Y/277-volt, and plug-in circuit breakers in 208Y/120 and 240/120-volt branch circuit panelboards.
4. Trip Mechanism:
    a. Individual permanent thermal and magnetic trip elements in each pole.
    b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
    c. Two and three pole, common trip.
    d. Automatically opens all poles when overcurrent occurs on one pole.
    e. Test button on cover.
    f. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
    a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
    b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection ofpersonnel).
    a. Ground fault sensor shall be rated same as circuit breaker.
    b. Push-to-test button.
    c. Reset button.
7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
8. Include a minimum of 10 percent spare unassigned breakers, including at least one three-pole device on a three-phase panelboard and three single pole 15-A breakers.
9. Also include 10 percent unfilled spaces available for future breaker installation. These shall be covered with blank cover plates.

H. Enclosures: Provide NEMA Rating required for the space as specified in Section 16050, Common Work Results for Electrical. Refer to the Plant Area Work Requirements table which specifies the permitted uses for these conduit types.

    1. Front cover shall be provided with a door within a door configuration with continuous hinged doors that are lockable for both the inner access and the front door providing access to the circuit breakers. The dead front shall be attached to the access door such then when opened the dead front swings open with the door.

I. Bus:

1. Material: Tin plated copper bus full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

J. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.

K. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.
4. Provide two ground bus bars, one on each side of the panelboard.

L. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.
4. Provide two neutral bus bars, one on each side of the panelboard.

M. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Front trim shall be secured to box with concealed trim clamps.
2. Surface-mount panelboard front trim shall have same dimensions as box.
3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.

5. Doors over 30 inches in height shall have multi-point latching.
6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
7. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.

2.04 POWER DISTRIBUTION PANELBOARDS

A. Branch Protective Devices:

1. Locking: Furnish devices with provisions for handle padlocking.
2. Load Connections: Wire lugs shall be mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
3. Provide a nameplate for each circuit, blanks for spares.

PART 3 EXECUTION

3.01 GENERAL

A. Installation per Section 16050, Common Work Results for Electrical.

B. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.

C. Install securely, plumb, in-line and square with walls.

D. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

E. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

F. Install filler plates in unused spaces.

G. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties with the help of adhesive backs.

H. Install all grounded and grounding conductors straight down to the respective grounded or grounding bus bar on each side of the panel. Do not cross grounded or grounding conductors across the panel interior.

I. Use cable tie mounting bases every 8 inches to rout all wiring neat and tidy.

1. Group grounding conductors.
2. Group natural conductors.
3. Ground phase conductors.

3.02 CONDUCTOR IDENTIFICATION

A. Individually label all ungrounded, grounded, and grounding conductors within the panelboard with the respective circuit number.

3.03 BRANCH CIRCUIT PANELBOARD

A. Provide machine-printed circuit directory for each panelboard.

B. Circuit directories shall be provided free of all Contractor logos, stickers, and marketing paraphernalia.

3.04 POWER DISTRIBUTION PANELBOARD

A. Provide engraved identification for each protective device.

END OF SECTION

SECTION 16444
LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Low voltage motor control centers.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. National Electrical Manufacturer's Association (NEMA): ICS 18-2001, Motor Control Centers.
3. UL: 845, Motor Control Centers.

1.03 DEFINITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Work in this section shall include modifying existing motor control centers. No new motor control centers are to be provided. The new bucket components shall be compatible with existing MCC bus rating and short circuit interrupted rating.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. Manufacturer of motor control center.
2. Manufacturer of motor control center parts.
3. Nameplate schedule.
4. Bill of material.
5. Enclosure:
   a. NEMA rating.
   b. Finish color.
6. Ratings:
   a. Voltage.
   b. Phase.
   c. Current:
      1) Horizontal bus ampacity.
      2) Vertical bus ampacity.
      3) Ground bus ampacity.
   d. Short circuit withstand rating.
   e. Protective device interrupting rating.
7. List of manufacturer's recommended spare parts.
8. Catalog Cut Sheets:
   a. Submit complete manufacturer's catalog information: Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
9. Furnish circuit breaker submittals as specified in Section 16050, Common Work Results for Electrical.
10. Submit a letter confirming each variable frequency drive (VFD) unit contained within the MCC has been coordinated with its respective driven load. Letter shall list VFD location and driven equipment tag numbers as well as the FLA rating of each driven load motor. Motor data sheets for each driven load motor shall be attached to the coordination letter for verification.
11. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050, Common Work Results for Electrical:
    a. Manufacturer's statement of seismic qualification with substantiating test data.
    b. Manufacturer's special seismic certification with substantiating test data.
12. List of manufacturer's recommended spare parts.

C. Shop Drawings:

1. Layout Drawings:
   a. Provide fully dimensioned and to scale layout drawings which include elevations of final modified motor control centers.
      1) Dimensions:
         a) Overall length.
         b) Overall width.
         c) Overall height.
         d) Overall weight and weight of individual shipping splits.
2. Interfaces to other equipment.
3. Allowable top and bottom conduit windows.
4. Complete component and unit layout drawings.
5. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
6. Elementary Schematics:
   a. Provide one custom schematic diagram for each compartment:
      1) Include all remote devices.
      2) Show wire numbers on the schematics: Provide wire numbering as specified in Section 16075, Electrical Identification.
7. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
8. One-line Diagrams:
   a. Provide complete one-line diagrams for each motor control center, including but not limited to: Protective devices, starters, drives, metering, and other equipment.
   b. Indicate electrical ratings of the equipment shown on the one-line diagrams.

D. Operation and Maintenance Manuals:

1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this section. Include the following:
   a. Electrical Ratings:
      1) Phase.
      2) Wire.
      3) Voltage.
      4) Ampacity.
      5) Protective device interrupting ratings.

b. Manufacturer's operating and maintenance instructions for the motor control center and all component parts, including:
   1) Starters.
   2) Overload relays and heater elements.
   3) Variable frequency drives.
   4) Protective devices including, but not limited to, fuses, circuit breakers and protective relays.
   5) Pilot devices.

E. Record Documents:

1. Elementary Schematics:
   a. Furnish as-built elementary schematics indicating final:
      1) Wire numbers.
      2) Interfaces with other equipment.
   b. Provide one custom schematic diagram for each compartment:
      1) Include all remote devices.
      2) Show wire numbers on the schematics.
   c. Layout Drawings: Provide complete dimensioned component and unit layout drawings.
2. The Record Documents shall reflect all modifications made during the submittal review process and during construction.

F. Calculations: Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

1.06 SPARE PARTS

A. No spare parts are required.

1.07 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.

1.08 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Ship the motor control center and associated equipment to the Job Site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment.

1.09 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.10 SEQUENCING

A. Conduct the initial fault current study as specified in Section 16950, Field Electrical Acceptance Tests, and submit results for Engineer's review.

B. After successful review of the initial fault current study, as specified in Section 16950, Field Electrical Acceptance Tests, submit complete equipment.

C. Submittal as specified in the Article Submittals, of this section for Engineer's review.

D. Conduct internal factory test to ensure that systems and equipment are functional and submit certified test results for Engineer's review.

E. Conduct factory acceptance test, to be witnessed by Owner and Owner's representative.

F. Ship equipment to the Project Site after successful completion of factory acceptance test.

G. Assemble equipment in the field.

H. Conduct field acceptance test and submit results for Engineer's review.

I. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.

J. Conduct Owner's training sessions.

K. Formally energize, start-up and commission equipment.

1.11 SCHEDULING

A. As specified in Section 16050, Common Work Results for Electrical.

1.12 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

1.13 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Eaton.
2. Allen-Bradley.
3. Schneider Electric.
4. “Or-equal.”

B. Existing Motor Control Centers: 715MCC4401, 20MCC99101, and 20MCC99102 are Eaton Freedom Series 2100.

2.02 EQUIPMENT

A. General:

1. Furnish motor control centers components as specified in the Contract Documents and indicated on the Drawings.
2. Provide wire markers at each end of every wire as specified in Section 16075, Electrical Identification.
3. Provide complete and functional motor control centers, even when modifying existing.
4. Provide devices or accessories not specified in this section but necessary for the proper installation and operation of the equipment.
5. Provide new components of the latest construction series available from the manufacturer.

B. Design and construct motor control center components to operate at the voltage level and configuration indicated on the Drawings.

C. Bus System: Existing, modifications required to extend bus to new vertical sections.

D. Enclosures: Existing, no modifications to existing footprint planned. Modifications shall occur in existing vertical sections for 715MCC4401. 20MCC99101 and 20MCC99102 require new vertical sections to be added. New vertical section shall match existing enclosure.

1. Enclosure Rating: Ensure that existing MCC ratings are maintained.
2. Wireways: Utilize existing wireways to accomplish the work.
3. Shipping Splits:
    a. No more than three vertical sections and not more than 60 inches in width.
    b. Solid bussing between vertical sections in a shipping split is not acceptable.
4. Lifting Angles:
    a. Furnish each vertical section and/or shipping split with a removable lifting angle mount to the top of the enclosure.
        1) Extending the entire width of the shipping split.
5. Mounting Channels: Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

E. Units:

1. A plug-in unit consists of:
    a. Unit assembly.
    b. Unit support pan.
    c. Unit door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Constructed so that any fault will be contained in the unit compartment.
4. Supported and guided by a removable unit support pan: Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
5. Held in place by screws or other positive locking means after insertion.
6. Provide a test position with the unit supported in the structure but disengaged from the bus.
7. Integral plug-in ground stab.
8. Stabs:
    a. Free floating.
    b. Self-aligning.
    c. Backed by spring steel clips to ensure high pressure contacts.
    d. Electrolytically tin-plated copper.

9. Handle:
    a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
    b. Door mounted operators or operator handles are not acceptable.
    c. Engaged with the disconnect device at all times as an integral part of the unit, independent of the door position.
    d. Lockable in the “OFF” position with up to three padlocks.
    e. Mechanically interlocked so that the door cannot be opened with the handle in the “ON” position.
        1) Provide a means for qualified personnel to defeat this interlock.
    f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the “ON” position.
    g. Lockable in the “ON” position:
        1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
    h. Color-coded to indicate position.
    i. Located so the center of the grip when it is in its highest position is not more than 6 feet 7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
10. Identification: The manufacturer shall label each unit. The units shall be labeled as shown on the Drawings.
11. Where indicated on the Drawings, provide units for spaces and future equipment:
    a. Equip these units to accept a future plug-in unit without modification to the vertical sections.

2.03 COMPONENTS

A. Provide components contained within the motor control center as specified in:

1. Section 16075, Electrical Identification.
2. Section 16123, 600-Volt or Less Wires and Cables.
3. Section 16150, Low Voltage Wire Connections.
4. Section 16262, Variable Frequency Drives 0.5 – 50 Horsepower.
5. Section 16422, Motor Starters.
6. Section 17710, Control Systems, Panels, Enclosures, and Components.

2.04 ACCESSORIES

A. Wiring:

1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
   a. NEMA Class II-S:
      1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
      2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e., electrical interlocking, etc., as specifically specified in the Contract Documents.
      3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
   b. NEMA Type B Wiring:
      1) Control Wiring: Type B-T pull-apart terminal blocks.
      2) All conductors shall be individually labeled using heat shrinkable tube labels. Each label shall be typewritten.
      3) Conductors color coding shall be as follows:
         a) Grounded Conductors: White.
         b) Grounding Conductors: Green.
         c) Ungrounding Conductors: Red.
      4) Wiring shall be MTW-type.
      5) Power Wiring:
         a) Type B-T for Size 1 starters.
         b) Type B-T or B-D for Size 2 and Size 3 starters.
         c) Type B for Size 4 and larger starters and feeder units.

B. Lugs and Terminals:

1. For all external connections of 6 AWG wire or larger: UL listed for copper or aluminum conductors.
2. Compression type, requiring a hydraulic press and die for installation.
3. Provide 20 percent spare control block terminals.

C. Nameplates:

1. Provide nameplates as specified in Section 16075, Electrical Identification: Identifying the motor control center designation as indicated on the Drawings.
2. Identifying each vertical section: Mounted and centered on the top horizontal wireway of the vertical section.

3. Furnish individual nameplates for each unit indicated on the Drawings:
   a. One nameplate to identify the unit designation.
   b. One nameplate to identify the load served.
   c. Furnish space units with blank nameplates.
4. Manufacturer's Labels:
   a. Furnish each vertical section with a label identifying:
      1) Serial number.
      2) Bus rating.
      3) Vertical section reference number.
      4) Date of manufacture.
      5) Catalog number of sections.

D. Pilot Devices:

1. Refer to Section 17710, Control Systems Panels, Enclosures, and Components.
2. Provide 30-mm size for all pilot devices.
3. Provide LED lights for all pilot lights.

2.05 FINISHES

A. Finish metal surfaces and structural parts with phosphatizing, "or-equal," treatment before painting.

B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.

C. Finish exterior of enclosure with manufacturer's standard gray.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install the equipment in accordance with the accepted installation instructions.

C. General:

1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
3. Make bus splice connections.

4. Perform work in accordance with manufacturer's instruction and Shop Drawings.
5. Furnish all components, and equipment necessary to complete the installation.
6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
7. Install MCC on 3-1/2-inch raised concrete housekeeping pad.
    a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
        1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
    b. Weld and/or bolt the motor control center frame to leveling channels.

D. Provide openings in the top or bottom of the motor control center for conduit only. For existing motor control centers, new conduits shall come out the top unless otherwise indicated on the Drawings.

E. Bundle Circuits Together and Terminate in Each Unit:

1. Tie with nylon wire ties as specified in Section 16123, 600-Volt or Less Wires and Cables.
2. Label all wires at each end with wire markers as specified in Section 16075, Electrical Identification, as shown on the approved elementary schematics.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

B. Provide the services of a manufacturer's representative to inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.03 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Demonstrate the operation of the motor control center to the Engineer's and Owner's satisfaction.

C. Training: Provide training for motor control center components as specified in the individual component specifications.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 16460
LOW VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes Requirements for:

1. Low Voltage Transformers.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data.
4. Schematic and connection diagrams.
5. Seismic anchorage and bracing drawings and cut sheets.
6. List of manufacturer's recommended spare parts.

1.03 SPARE PARTS

A. No spare parts are required.

1.04 SEISMIC REQUIREMENTS

A. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612, Anchorage and Bracing.

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed values in Table 4.2 of NEMA TP 1.

E. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.

F. Overload Capability: Short-term overload per IEEE C57.96.

G. Vibration Isolators:

1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

H. Manufacturers:

1. General Electric Co.
2. Square D Co.
3. Eaton/Cutler-Hammer.

2.02 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units.
3. 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
3. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.

D. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 4.5 percent minimum on units 75 kVA and larger.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. All grounding and bonding in the transformer before any panelboard.

END OF SECTION

SECTION 16510
LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: LED luminaires, drivers, poles, and accessories.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 01756, Testing and Facility Startup.
3. Section 16050, Common Work Results for Electrical.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. Illuminating Engineering Society of North America (IESNA):
   a. LM-79, Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
   b. LM-80, Approved Method: Measuring Lumen Maintenance of LED Light Sources.
   c. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.
3. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturers Association (NEMA): 410, Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
5. UL:
   a. 1598, Luminaires.
   b. 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.03 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Product Data:

1. LED Luminaires:
   a. Catalog literature for each luminaire specified, cross- referenced to the luminaire type on the Luminaire Schedule on the Drawings.
   b. Provide for each Luminaire Type:
      1) Materials.
      2) Type of diffuser.
      3) Hardware.
      4) Gasketing.
      5) Reflector.
      6) Chassis.
      7) Finish and color.
      8) Driver type and protection.
      9) LED Luminaire:
         a) Initial lumen output at 40 degrees C ambient.
         b) Correlated color temperature.
         c) Lumen maintenance factors.
         d) Lumen ambient temperature multipliers.
         e) Drive current.
         f) Efficacy.
      10) Picture of luminaire.
      11) Dimensioned Drawings: Effective projected area rating for pole mounted luminaires.
      12) Weight.
      13) Photometric Data:
         a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
         b) Luminaire dirt depreciation factor.
         c) Candlepower distribution curves.
         d) Average luminaire brightness.
         e) Lumen output charts.
      14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
         a) Support methods shall be based on seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical.

2. Driver:
    a. Provide for each driver type:
        1) Catalog number.
        2) Type of driver.
        3) Output wattage.
        4) Input voltage.
        5) Operating voltage range.
        6) Maximum input power.
        7) Efficiency.
        8) Operating line current.
        9) Power factor.
        10) Operating temperature range.
        11) Current output range in ambient temperatures of 30 degrees C to 55 degrees C.
        12) Surge suppression data.
3. Luminaire Poles:
    a. Submit complete data for each pole type including but not limited to:
        1) Material.
        2) Finish and color.
        3) Handholes.
        4) Anchoring.
        5) Luminaire attachment methods and fittings.
        6) Pole height.
        7) Pole dimensions.
        8) Bolt hole circle layout and hardware.
        9) Accessories.
        10) Provide the EPA wind load rating.

C. Calculations:

1. Provide complete design calculations and installation documents for poles mounted from structures:
    a. Include in the calculations the wind and seismic requirements at the Project Site.
    b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the Project is being constructed.

D. List of manufacturer’s recommended spare parts.

E. Record Documents: Update the Luminaire Schedule on the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.05 SPARE PARTS

A. No spare parts are required.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Unwrap all pole lights when they arrive onsite.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

B. LED Luminaire: 5-year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.10 SYSTEM STARTUP

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires:

1. One of the following:
   a. As noted on the Luminaire Schedule on the Drawings.

B. Drivers:

1. One of the following:
   a. Philips Advance.
   b. Thomas Research.
   c. eldoLED.
   d. “Or-equal.”

C. Timer Controls:

1. One of the following:
   a. Intermatic.
   b. “Or-equal.”

D. Substitutions: The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor’s responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EQUIPMENT

A. LED Luminaires:

1. General:
   a. Pre-wired with leads of 18 AWG, minimum, for connection to building circuits.
   b. Provide the luminaires furnished per the Luminaire Schedule on the Drawings: The Specifications noted herein are an addition or supplement to the Luminaire Schedule on the Drawings.
   c. Individual LEDs connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
2. Minimum ambient temperature range of 0 degree C to 40 degrees C.
3. Minimum Rated Life:
   a. Office Areas: Minimum 70,000 hours when operated at 25 degrees C.
   b. Process Areas: Minimum 100,000 hours when operated at 40 degrees C.
4. Minimum efficacy of 70 lumens/watt.
5. Minimum Color Rendering Index of 80.
6. Tested according to IESNA LM-79 and LM-80.
7. Lumen maintenance projection in accordance with IESNA TM-21.
8. RoHS compliant.
9. Integral driver.
10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
    a. Wet or Damp Locations: UL 1598 listed.

11. Exterior/Outdoor Luminaires:
    a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
        1) Wind levels at the Project Site without damage.
        2) Seismic levels at the Project Site.
    b. Stainless steel hardware and hinged doors or lens retainer.

B. Cord and Plug Connected Luminaires: All luminaires installed indoors within process areas, tunnels, electrical, and mechanical rooms shall be cord and plug connected.

1. Order with factory cord whips.
2. Install the cord ends in the field as mounting.
    a. Leave 12-inch courtesy loop, cut off any extra.

C. Timer Controls:

1. Outdoor lights shall be controlled from astronomical timer inside the lighting contactor located in the Electrical Room.
2. Indoor lighting shall be controlled from 2-hour timers located at the entry to each area.
3. Where indoor light fixtures in one area are powered by multiple 120V circuits, the lights shall be controlled from the lighting contactor located in the Electrical Room.
4. 2-hour timers shall be Intermatic; FF32, “or-equal.”

2.03 POLES

A. Hinged pole base. The hinges shall be installed so that the pole can be laid down flat in an accessible area.

B. Material, Size, and Shape: As shown on the Drawings.

C. GFCI receptacle with complete weatherproof metal cover on pole. Locate the receptacle such that it is accessible from the ground or walking surface.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 16050, Common Work Results for Electrical.

B. Install luminaires per the manufacturer’s guidelines and submitted installation calculations to meet seismic and wind requirements at the Project Site.

C. Luminaire Poles:

1. Set poles on anchor bolts and secured with double nuts on each bolt.
2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole.
    a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

D. Orientate hinge to lay-down pole in unobstructed area.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 16050, Common Work Results for Electrical.

3.04 ADJUSTING

A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.05 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

B. Clean all lenses, diffusers, and reflectors. Refinish all luminaires' trim, poles, and support brackets, where finish has been damaged. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.06 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

3.07 SCHEDULES

A. Refer to the Luminaire Schedule on the Drawings.

END OF SECTION

SECTION 16611
UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies an on-line, double conversion single-phase uninterruptible power supply (UPS) system to provide backup power for the Digester Complex 1 (DC1) waste gas burner system at the Durham Wastewater Treatment Facility.

B. The UPS equipment includes a UPS comprising a rectifier/charger; pulse-width-modulation inverter; displays and controls; discrete relay outputs; make-before-break, wrap-around maintenance bypass switch; DIN rail mounted circuit breakers and terminals for load outputs; wall-mounted enclosure; and appurtenances.

C. The UPS integration services include installation, configuration, commissioning, and training for a completely operational UPS system.

1.02 RELATED SECTIONS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

C. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

D. Section 01330, Submittal Procedures.

E. Section 01612, Anchorage and Bracing.

F. Section 16050, Common Work Results for Electrical.

G. Section 16075, Electrical Identification.

1.03 QUALITY ASSURANCE

A. Referenced Standards: This section incorporates by reference the latest revisions of the following documents. In case of conflict between the requirements of this section and the listed documents, the requirements of the Contract Specifications shall prevail.

Reference	Title
IEEE 485	Recommended Practice for Sizing Lead – Acid Batteries for Stationary Applications
NFPA 70 UL1778	National Electrical Code (NEC) Uninterruptible Power Supply Equipment

B. Label: UPS equipment shall bear a UL or other label acceptable to the inspection authority having jurisdiction for the specific application and be UL1778 listed.

C. Manufacturer shall have a minimum of 5 years in the design, manufacture, and testing of solid-state UPS systems.

D. Prior to shipment, the manufacturer shall fully and completely test the system to assure compliance with these specifications and shall include as a minimum: Operational discharge and recharge tests to guarantee rated performance.

1.04 SUBMITTALS

A. Procedure: Section 01330, Submittal Procedures.

B. Catalog cuts showing general features of the UPS and batteries.

C. Battery discharge/recharge calculations showing a minimum of 20 minutes backup time for the specified downstream loads including: 120V ac/2A waste gas burner control panel; 120V ac/1A valve actuator; 120V ac/0.2A flow transmitter.

D. Dimensions and weights of components including working clearances.

E. Block diagram depicting functional operation of UPS.

F. Configuration instructions for dry contact relay outputs.

G. Installation instructions and drawings.

H. Cabling and termination requirements.

I. Maximum input and output current.

J. Wiring diagrams, internal and external.

K. User's manual.

1.05 PERFORMANCE REQUIREMENTS

A. Equipment AC Input Characteristics:

1. Normal Source: 120V ac, single-phase, 3-wire.
2. Operating Voltage Range: Plus 10 percent to minus 15 percent (minus 20 percent without battery discharge).
3. Frequency Range: 40 Hz to 70 Hz.
4. Input Current Distortion: 5 percent total harmonic distortion maximum at full load.
5. Input Power Factor: 0.98 lagging at full load.
6. Surge Protection: Sustains input surges without damage per IEEE C62.41, Category B.

B. Equipment ac Output Characteristics:

1. Voltage: 120V ac, single-phase, 3-wire.
2. Voltage Regulation: Plus or minus 3 percent nominal for no load to full load.
3. Frequency Regulation: 60 Hz plus or minus 5 percent.
4. Frequency Synchronized to Power Source: Automatic disconnect at plus or minus 0.5 Hz.
5. Output Power Rating: 1,500VA at 0 degrees C to 40 degrees C ambient.
6. Voltage Transient Response: Plus or minus 7 percent maximum upon application or removal of 50 percent to 100 percent load step; recovery to plus or minus 1 percent of steady state within 100 mS.
7. Overload Capability: 150 percent for 2 seconds.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Ambient temperature ranges from 50 degrees F to 95 degrees F.

B. Elevation above sea level is 0 feet to 500 feet.

C. Relative humidity 5 percent to 95 percent, non-condensing.

1.07 SEISMIC ANCHORAGE AND STRUCTURAL DATA

A. Mechanical, instrumentation and control, electrical, nonstructural systems, components, and elements permanently attached to the structure shall be anchored and braced to resist seismic forces. Contractor shall design the structural components, seismic attachment, braces, and anchors to the structure.

1.08 EXTENDED WARRANTY

A. In addition to the manufacturer's standard warranty, the Contractor shall repair or replace without charge to the District, any equipment or part thereof, that the Contractor supplies that fails in operation during normal use within two years from the date of acceptance of the UPS system.

PART 2 PRODUCTS

2.01 CANDIDATE MANUFACTURERS/PRODUCTS

A. The UPS system shall be capable of providing 1,500VA. Acceptable manufacturer includes the following:

1. Eaton 9SX 1500VA UPS with Industrial Relay Card.
2. "Or-equal."

2.02 GENERAL

A. All materials and components shall be new and currently manufactured.

B. UPS shall be a true on-line system designed to operate in the following modes:

1. Normal: Load is powered by the UPS inverter, which obtains power from upstream normal power.
2. Back-Up: Load is powered by the UPS inverter, which obtains power from the battery automatically without interruption, and returns to upstream normal power without interruption.
3. Recharge: Upon restoration of upstream normal power, the input converter shall automatically restart and resume supplying power. The battery charger shall then recharge the batteries.
4. Automatic Restart: Upon restoration of upstream normal power after a power failure that resulted in complete battery discharge, the UPS shall automatically restart and resume supplying power to the load and the battery charger shall automatically recharge the batteries, unless disabled or delayed by the user.

5. Automatic Bypass: UPS failure shall automatically cause the load to transfer from the inverter to the bypass.
6. Manual Bypass: Shall cause an immediate transfer of load from the inverter to the bypass source without disruption to input converter, inverter, and battery charger functions.

2.03 CONVERTER/INVERTER

A. Converter:

1. Input converter changes incoming ac power to a regulated dc output to the inverter and provides input power factor and input current distortion correction. The input converter shall be provided with:
   a. Undervoltage protection (including low-energy surges introduced on the primary source and bypass source).
   b. Overvoltage protection.
   c. Capability to sustain input surges without damage per IEEE C62.41, Categories A and B.

B. Inverter:

1. Output inverter converts dc power from the input converter or batteries into precise regulated ac power sine waves. The inverter shall be:
   a. Capable of supplying current and voltage for overloads up to 150 percent of full load current for up to 10 seconds.
   b. For currents greater than 150 percent or longer time durations, the inverter electronic current-limiting protection shall protect the inverter regardless of the magnitude of connected output overload.
   c. Capable of providing control logic to sense overload and disconnect from critical load without needing to clear protective fuses, and to shutdown voltage set point to prevent battery damage from discharging.
   d. Automatically transfer to bypass when any of the above conditions are exceeded.

2.04 BATTERY

A. Provide the required number of battery modules to meet a reserve time of 20 minutes at loads specified.

B. Batteries shall be sealed maintenance-free, lead acid type with a three-year to five-year life expectancy.

2.05 UPS MONITORING AND CONTROLS

A. UPS Local Display and Alarms:

1. Front panel LEDs and LCD display shall indicate and alarm the following:
   a. Indicate Only:
      1) AC Input Failure.
      2) On Battery Power.
      3) Load On/Off.
      4) On Inverter.
   b. Indicate and audibly alarm:
      1) Replace Battery Module.
      2) Replace Power Module.
      3) Replace Control Module.
      4) On Bypass.
      5) Low Battery.
      6) Over Temp Warning.
      7) UPS Shutdown.
      8) Output Undervoltage.
      9) Output Overvoltage.
      10) DC bus Overvoltage.
   c. Upon fault condition, the UPS shall attempt to maintain load or transfer load to bypass.
   d. UPS shall be provided with an audible alarm silence button.

B. The UPS shall be provided with 125V ac/5A, form C, relay contacts for the following:

1. AC Input Failure.
2. On Battery.
3. Low Battery.
4. On Bypass.
5. UPS Fault.

C. UPS Control:

1. Initiate automatic battery test either on a user defined periodic schedule or user defined date and time.
2. Automatic UPS bypass circuit shall transfer the load to the bypass source based on:
   a. Inverter overload capacity exceeded.
   b. Inverter over temp.
   c. UPS fault condition.

3. Automatic UPS bypass circuit shall transfer the load, without exceeding transient limits, when an overload or malfunction occurs within the UPS. The bypass shall have an overload rating of 200 percent rated full load for 10 cycles. Automatic bypass shall be inhibited if one of the following conditions exist:
   a. Inverter/bypass voltage difference exceeds preset limits (plus or minus 15 percent of nominal).
   b. Bypass frequency is out of preset limits (plus or minus 5 percent of nominal frequency).
4. Automatic retransfer of the load back to the UPS shall occur unless:
   a. It is inhibited by manual control.
   b. Bypass is out-of-synchronization range with inverter output.
   c. Overload condition exists in excess of the inverter full load rating.
   d. There is a UPS fault condition present.
5. Manual internal UPS bypass circuit shall allow power to bypass the rectifier, battery charger, inverter, and battery.

2.06 MAINTENANCE BYPASS SWITCH POWER DISTRIBUTION UNIT

A. Mounted in common enclosure with UPS.

B. Provides complete “wrap-around” protection to allow the UPS to be pulled from service. The “wrap-around” allows the electrical load to be connected to the upstream normal power during UPS and battery maintenance. Provide a make-before-break bypass for the UPS and battery without shutting down the load.

C. Acceptable product is the rack-mountable Eaton HotSwap MBP Catalog No. EHBPL1500R-PDU1U “or-equal.”

2.07 DIN RAIL, OUTPUT CIRCUIT BREAKER AND TERMINALS ASSEMBLY

A. Provide a rack-mounted 35 mm DIN rail assembly complete with output circuit breakers, terminals and internal wiring as shown on the Drawings.

2.08 RACK ENCLOSURE

A. Enclosure:

1. UPS, maintenance bypass switch PDU, and DIN rail assembly shall be housed in a wall-mounted, NEMA 1, 15 bay (15U) rack enclosure.
2. Acceptable product is NavePoint 00406210 “or-equal.”

B. Enclosure Sliding Shelf:

1. Include slide shelving for UPS for ease of maintenance.
2. Shelf: 1-bay (1U) vented sliding 4-post adjustable shelf with weight capacity to handle equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:

1. Install uninterruptible power supply, maintenance bypass PDU and DIN rail for output load interconnection in the wall-mounted 15U rack enclosure as shown on the Drawings. Installation per the manufacturer's installation instruction.
2. Wall mount the UPS panel at the approximate location shown on the Drawings. Coordinate final location with the Owner. Provide seismic anchorage and bracing.
3. Mount equipment near front of enclosure.

3.02 FIELD TESTING

A. In addition to any testing herein, perform all testing for this product or system consistent with the requirements of applicable codes, and the manufacturer's current quality assurance program.

B. Test prior to operational use.

C. Load Test:

1. Use 0.8 power factor load bank.
2. Disconnect ac input and operate UPS at rated load.
3. Record operating time and battery voltage.
4. Continue operation at rated load battery cutoff.
5. Monitor battery voltage and record value just prior to cutoff.

D. Battery Recharge Test: Connect ac power to each battery module in low batter state and record battery specific gravity. Allow battery module to be charged and record battery specific gravity at end of specified recharge duration.

E. Relay Output Test: Verify relay outputs are correctly configured. Verify that "UPS Fail" contacts are wired to and correctly monitored by 120V ac digital input at PLC panel. Verify that "AC Input Fail" contacts are wired to and correctly monitored by "Full Open Override" input at actuator for flow valve.

END OF SECTION

SECTION 16950
FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Responsibilities for testing the electrical installation.
2. Adjusting and calibration.
3. Acceptance tests.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 01756, Testing and Facility Startup.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16060, Grounding and Bonding.

C. Copyright Information: Some portions of this section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 16050, Common Work Results for Electrical.
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
    a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
    b. D923, Standard Practices for Sampling Electrical Insulating Liquids.
    c. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
    d. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
    e. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
    f. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
    g. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
    h. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
    i. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
    j. D3612, Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
4. Institute of Electrical and Electronics Engineers (IEEE):
    a. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
    b. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
    c. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2,300 V and Above) With High Direct Voltage.
    d. 421.3, Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
    e. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
    f. 1106, Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.

g. 1188, Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
h. C57.13, Standard Requirements for Instrument Transformers.
i. C57.13.1, Guide for Field Testing of Relaying Current Transformers.
j. C57.13.3, Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
k. C57.104, Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

5. Insulated Cable Engineer's Association (ICEA).
6. InterNational Electrical Testing Association (NETA): ATS-2021, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
7. International Electrotechnical Commission (IEC).
8. Manufacturer's testing recommendations and instruction manuals.
9. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 110, Standard for Emergency and Standby Power Systems.
10. National Institute of Standards and Technology (NIST).
11. Specification sections for the electrical equipment being tested.
12. Shop Drawings.

1.03 DEFINITIONS

A. As specified in Section 01756, Testing and Facility Startup, and Section 16050, Common Work Results for Electrical.

B. Specific Definitions:

1. Testing Laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative: The Engineer will witness all visual, mechanical, and electrical tests and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:

1. Contractor Responsibilities: Ensure that all resources are made available for testing, and that all testing requirements are met.
2. Electrical Subcontractor Responsibilities:
   a. Perform routine tests during installation.
   b. Demonstrate operation of electrical equipment.
   c. Commission the electrical installation.
   d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
      1) Providing electrical power as required.
      2) Operating of electrical equipment in conjunction with testing of other equipment.
      3) Activating and shutting down electrical circuits.
      4) Making and recording electrical measurements.
      5) Replacing blown fuses.
      6) Installing temporary jumpers.
3. Testing Laboratory Responsibilities:
   a. Perform all acceptance tests specified in this section.
   b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 16050, Common Work Results for Electrical.

B. Manufacturers' Testing Procedures: Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

C. Test Report:

1. Include the following:
   a. Summary of Project.
   b. Description of equipment tested.
   c. Description of tests performed.
   d. Test results.
   e. Conclusions and recommendations.
   f. Completed test forms.
   g. List of test equipment used and calibration dates.

D. Testing Laboratory Qualifications:

1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
   a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
      1) Corporate history and references.
      2) Resume of individual performing test.
      3) Equipment list and test calibration data.

E. Division of Responsibilities: Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050, Common Work Results for Electrical.

B. Testing Laboratory Qualifications:

1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050, Common Work Results for Electrical.

1.08 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:

1. Perform routine tests as the equipment is installed including:
   a. Insulation-resistance tests.
   b. Continuity tests.
   c. Rotational tests.
2. Adjusting and preliminary calibration.

3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant startup.

1.09 WARRANTY

A. As specified in Section 16050, Common Work Results for Electrical.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Test Instrument Calibration:

1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
2. The accuracy shall be traceable to the NIST in an unbroken chain.
3. Calibrate instruments in accordance with the following frequency schedule:
   a. Field Instruments: 12 months maximum.
   b. Laboratory Instruments: 12 months maximum.
   c. Leased Specialty Equipment where the Accuracy is Guaranteed by the Lessor (such as Doble): 12 months maximum.
4. Dated calibration labels shall be visible on all test equipment.
5. Maintain an up-to-date instrument calibration record for each test instrument: The records shall show the date and results of each calibration or test.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:

1. All instruments required are available and in proper operating condition.
2. All required dispensable materials such as solvents, rags, and brushes are available.
3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.02 TESTING AND FACILITY STARTUP

A. As specified in Section 01756, Testing and Facility Startup.

3.03 FIELD QUALITY CONTROL

A. PANELBOARDS

1. Visual and Mechanical Inspection: Include the following inspections and related work:
   a. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
   b. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
   c. Check panelboard mounting, area clearances, and alignment and fit of components.
   d. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values or NETA ATS, Table 100.12 .
   e. Perform visual and mechanical inspection for overcurrent protective devices.
2. Electrical Tests:
   a. Include the following items performed in accordance with manufacturer's instruction:
      1) Insulation Resistance Tests:
         a) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
         b) Each phase of each bus section.
         c) Phase-to-phase and phase-to-ground for 1 minute.
         d) With breakers OPEN.
         e) With breakers CLOSED.
         f) Control wiring except that connected to solid state components.
         g) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
      2) Ground continuity test ground bus to system ground.
3. Perform resistance measurements through bolted electrical connections with low-resistance ohmmeter. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

B. Low Voltage Cables, 600-volt Maximum:

1. Visual and Mechanical Inspection:
   a. Compare cable data with the Drawings and Specifications.
   b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
   c. Inspect bolted electrical connections for high resistance by one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   d. Inspect compression applied connectors for correct cable match and indentation.
   e. Inspect for correct identification and arrangement.
   f. Inspect cable jacket insulation and condition.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
      1) Applied potential shall be 500V dc for 300-volt rated cable and 1,000V dc for 600-volt rated cable.
      2) Test duration shall be 1 minute.
   c. Perform continuity tests to ensure correct cable connection.
   d. Verify uniform resistance of parallel conductors.
3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data. Use Table 100.1.Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   c. Cable shall exhibit continuity.
   d. Investigate deviations in resistance between parallel conductors.

C. Low Voltage Molded Case and Insulated Case Circuit Breakers:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with the Contract Documents.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage and alignment.
   d. Verify the unit is clean.
   e. Operate circuit breaker to ensure smooth operation.
   f. Inspect bolted electrical connections for high resistance by one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   g. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
   h. Perform adjustments for final protective device settings in accordance with the coordination study.
   i. Record as-found and as-left operation counter readings.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
      1) Apply voltage in accordance with manufacturer's published data.
      2) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Perform a contact/pole-resistance test.
   d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500V dc for 300-volt rated cable and 1,000V dc for 600V rated cable. Apply the test voltage for 1 minute: For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
   e. Determine long-time pickup and delay by primary current injection.
   f. Determine short-time pickup and delay by primary current injection.
   g. Determine ground-fault pickup and delay by primary current injection.
   h. Determine instantaneous pickup value by primary current injection.

i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
j. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition: Reset all trip logs and indicators.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Insulation-resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data: If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   e. Insulation-resistance values of control wiring shall not be less than 2 megohms.
   f. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors: If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
   g. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   h. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   i. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances: Refer to NETA ATS tables in the absence of manufacturer's published data.
   j. Pickup values and trip characteristics shall be within manufacturer's published tolerances.

k. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
l. Breaker OPEN, CLOSE, trip, trip-free, antipump, and auxiliary features shall function as designed.
m. The charging mechanism shall operate in accordance with manufacturer's published data.

D. Circuit Breakers – Low-Voltage, Power:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with the Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify that all maintenance devices are available for servicing and operating the breaker.
   e. Verify the unit is clean.
   f. Verify the arc chutes are intact.
   g. Inspect moving and stationary contacts for condition and alignment.
   h. Verify that primary and secondary contact wipe and other critical dimensions are correct.
   i. Perform mechanical operator and contact alignment tests on breaker and operating mechanism per manufacturer.
   j. Inspect bolted electrical connections for high resistance using:
      1) Low-resistance ohmmeter.
      2) Calibrated torque-wrench per manufacturer or NETA.
   k. Verify cell fit and element alignment.
   l. Verify racking mechanism operation
   m. Verify appropriate lubrication on movi.ng current-carrying parts and sliding surfaces.
   n. Perform adjustments for final protective device settings per coordination study.
   o. Record as-found and as-left operation counter readings.
2. Electrical Tests:
   a. Measure resistance of bolted connections with low-resistance ohmmeter.
   b. Perform insulation-resistance tests (1 minute):
      1) Phase-to-phase and phase-to-ground with breaker CLOSED.
      2) Across each OPEN pole.
      3) Test voltage per manufacturer or NETA.
   c. Perform contact/pole-resistance test.

d. Perform insulation-resistance tests on all control wiring with respect to ground:
   1) 500 Vdc for 300 V rated cable.
   2) 1000 Vdc for 600 V rated cable.
   3) Duration: 1 minute.
   4) Follow manufacturer's recommendation for solid-state units.
e. Determine long-time pickup and delay by primary current injection.
f. Determine short-time pickup and delay by primary current injection.
g. Determine ground-fault pickup and delay by primary current injection.
h. Determine instantaneous pickup by primary current injection.
i. Test functions of the trip unit by secondary injection.
j. Perform minimum pickup voltage tests on shunt trip and close coils per manufacturer or NETA.
k. Verify operation of auxiliary features:
   1) Trip and pickup indicators.
   2) Zone interlocking.
   3) Electrical close and trip operation.
   4) Trip-free and anti-pump functions.
   5) Trip unit battery condition.
   6) Reset trip logs and indicators.
l. Verify charging mechanism operation

3. Test Values – Visual and Mechanical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Torque levels per manufacturer's published data or NETA.
   c. Settings must comply with coordination study recommendations.
   d. Operations counter must advance one digit per close-open cycle.
4. Test Values – Electrical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Insulation-resistance values must meet manufacturer's data or NETA; investigate values below minimum.
   c. Contact/pole resistance must not exceed normal range; investigate greater than 50 percent deviation from similar breakers.
   d. Long-time pickup and trip characteristics must match manufacturer's data or NETA.
   e. Short-time pickup and trip characteristics must match manufacturer's published band.
   f. Ground-fault pickup and trip characteristics must match manufacturer's published band.

g. Instantaneous pickup must be within manufacturer's tolerances or per NETA.
h. All pickup and trip characteristics must remain within specified tolerances
i. Minimum pickup voltage for shunt trip and close coils must match manufacturer's data or NETA.
j. Auxiliary features must function per manufacturer's data.
k. Charging mechanism must function per manufacturer's data.

E. Grounding Systems:

1. Visual and Mechanical Inspection:
   a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the NEC.
   b. Inspect physical and mechanical condition.
   c. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   d. Inspect anchorage.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
   c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
3. Test Values:
   a. Grounding system electrical and mechanical connections shall be free of corrosion.
   b. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   c. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
   d. The resistance between the main grounding electrode and ground shall be as specified in Section 16060, Grounding and Bonding. Investigate point-to-point resistance values that exceed 0.5 ohm.

F. Motor Starters, Low Voltage:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment and grounding.
   d. Verify the unit is clean.
   e. Inspect Contactors:
      1) Verify mechanical operation.
      2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
   f. Motor-running Protection:
      1) Verify overload element rating is correct for its application.
      2) If motor running protection is provided by fuses, verify correct fuse rating.
   g. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method: Refer to manufacturer's instructions for proper foot-pounds levels or NETA ATS tables.
      3) Thermographic survey.
   h. Lubrication Requirements:
      1) Verify appropriate lubrication on moving current-carrying parts.
      2) Verify appropriate lubrication on moving and sliding surfaces.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
   b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
      1) Test voltage shall be in accordance with manufacturer's published data.
      2) Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
   1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
d. Test motor protection devices in accordance with manufacturer's published data.
e. Test circuit breakers as specified in this section.
f. Perform operational tests by initiating control devices.
g. Perform electrical tests of input circuit breaker as specified in this section.
h. Measure fuse resistance.

3. Test Values:
   a. Compare bolted connection resistance values to values of similar connections: Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data: Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
   d. Test values for input circuit breaker shall be as specified in this section.
   e. Relay calibration results shall be as specified in this section.
   f. Continuity of bonding conductors shall be as specified in this section.
   g. Control devices shall perform in accordance with system requirements.
   h. Operational tests shall conform to system design requirements.
   i. Investigate fuse resistance values that deviate from each other by more than 15 percent.

F. Automatic transfer switch:

1. Visual and Mechanical Inspections:
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify unit is clean.

e. Verify appropriate lubrication on moving current-carrying parts and sliding surfaces.
f. Verify manual-transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted connections for high resistance using:
    1) Low-resistance ohmmeter.
    2) Calibrated torque-wrench per manufacturer's published data or NETA.
i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.

2. Electrical Tests:
    a. Measure resistance of bolted connections with low-resistance ohmmeter.
    b. Insulation-resistance test, 1 minute, on each pole (phase-to-phase & phase-to-ground) with switch in both source positions and across each open pole; voltage per manufacturer's data or NETA.
    c. Perform contact/pole-resistance test.
    d. Verify settings and operation of all control devices.
    e. Calibrate and set all relays and timers.
    f. Verify phase rotation, phasing, and synchronized operation as required.
    g. Verify correct operation and timing of:
        1) Normal-source voltage- and frequency-sensing relays.
        2) Engine start sequence.
        3) Time delay on transfer.
        4) Alternate-source voltage- and frequency-sensing relays.
        5) Automatic transfer operation.
        6) Interlocks and limit-switch function.
        7) Time delay and retransfer on normal-power restoration.
        8) Engine cool-down and shutdown feature.
3. Test Values – Visual and Mechanical:
    a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
    b. Bolt-torque levels per manufacturer's published data or NETA.
4. Test Values – Electrical:
    a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
    b. Insulation-resistance values of transfer switch poles per manufacturer's published data or NETA; investigate below-minimum values.
    c. Microhm or DC millivolt drop shall not exceed manufacturer's normal high range; investigate deviations greater than 50 percent of lowest value.

d. Control devices shall operate per manufacturer's published data.
e. Relay test results acceptable.
f. Phase rotation, phasing, and synchronization per system design.
g. Operation and timing per manufacturer's and system design requirements.

G. Motor Control - Motor Starters, Low Voltage:

1. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding and required clearances.
   d. Verify the unit is clean.
   e. Inspect contactors:
      1) Verify mechanical operation.
      2) Verify contact gap, wipe, alignment, and pressure per manufacturer's data.
   f. Motor-running protection:
      1) Verify overload element rating or protection settings are correct for application.
      2) If protection is provided by fuses, verify correct fuse rating.
   g. Inspect bolted electrical connections for high resistance using:
      1) Low-resistance ohmmeter.
      2) Calibrated torque-wrench per manufacturer or NETA.
   h. Verify appropriate lubrication on moving current-carrying parts and sliding surfaces.
2. Electrical Tests:
   a. Measure resistance through bolted connections with low-resistance ohmmeter.
   b. Perform insulation-resistance tests (1 minute):
      1) Phase-to-phase and phase-to-ground with starter closed.
      2) Across each open pole.
      3) Test voltage per manufacturer or NETA.
   c. Test motor protection devices per manufacturer's data or NETA Section 7.9.
   d. Test circuit breakers per NETA Section 7.6.1.1
   e. Perform operational tests by initiating control devices.
3. Test Values – Visual and Mechanical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Torque levels per manufacturer's published data or NETA.

4. Test Values – Electrical:
    a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
    b. Insulation-resistance values must meet manufacturer's data or NETA; investigate below-minimum readings.
    c. Motor protection parameters must match manufacturer's data or NETA Section 7.9.
    d. Circuit breaker test results must comply with NETA Section 7.6.1.1.
    e. Control devices must perform per system design and/or requirements.

H. Panelboard Assemblies:

1. Visual and Mechanical Inspection:
    a. Compare equipment nameplate data with the Drawings and Specifications.
    b. Inspect anchorage, alignment, grounding, and required area clearances.
    c. Verify unit is clean and all shipping bracing, loose parts, and cubicle documentation have been removed.
    d. Verify fuse and circuit-breaker sizes/types match drawings, coordination study, and microprocessor-communication package addresses.
    e. Verify wiring connections are tight and secure to prevent damage during moving-parts operation.
    f. Inspect bolted connections for high resistance using:
        1) Low-resistance ohmmeter.
        2) Calibrated torque-wrench per manufacturer's published data or NETA.
    g. Confirm correct operation and sequencing of interlocks:
        1) Attempt closure on locked-OPEN devices; attempt opening locked-closed devices.
        2) Perform key exchange for all interlock devices.
    h. Inspect insulators for physical damage or contamination.
    i. Exercise all active components.
    j. Verify filters are in place and vents are clear.
    k. Perform visual/mechanical inspection of surge arresters per this specification.
2. Electrical Tests:
    a. Measure resistance of bolted connections with low-resistance ohmmeter.

b. Perform insulation-resistance test on each bus section (phase-to-phase and phase-to-ground), 1 minute duration, voltage in accordance with NETA.
c. Perform ground-resistance test per this specification.
d. Perform surge-arrester electrical tests per this specification.

3. Test Values – Visual and Mechanical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Verify bolt-torque levels per manufacturer's published data or NETA.
4. Test Values – Electrical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Verify bus insulation resistance per manufacturer's published data or NETA; investigate values below minimum.
   c. Confirm correct phasing via phasing checks.
   d. Confirm surge-arrester test results meet this specification.

I. Transformers, Dry-Type, Air-Cooled, Low-Voltage, Small (600 V or less, less than or equal to 167 kVA single-phase or less than or equal to 500 kVA three-phase).

1. Visual and Mechanical Inspections:
   a. Compare equipment nameplate data with the Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify resilient mounts are free and shipping brackets have been removed.
   e. Verify the unit is clean.
   f. Inspect bolted electrical connections for high resistance using:
      1) Low-resistance ohmmeter.
      2) Calibrated torque-wrench per manufacturer's published data or NETA.
   g. Verify as-left tap connections match specifications.
2. Electrical Tests:
   a. Measure resistance of bolted connections with low-resistance ohmmeter.
   b. Perform insulation-resistance tests winding-to-winding and winding-to-ground; apply voltage per manufacturer's data or NETA; calculate dielectric absorption ratio.
   c. Perform turns-ratio tests at the designated tap position.
   d. Verify secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3. Test Values – Visual and Mechanical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Bolt-torque levels per manufacturer's published data or NETA.
4. Test Values – Electrical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of lowest value.
   b. Minimum insulation-resistance per manufacturer's data or NETA; investigate below-minimum; dielectric absorption ratio greater than or equal to 1.0.
   c. Turns-ratio test results shall not deviate by more than 0.5 percent from adjacent coils or calculated ratio.
      1) Secondary voltages (phase-to-phase & phase-to-neutral) must agree with nameplate data.

J. SURGE ARRESTERS – Low-Voltage:

1. Visual and Mechanical Inspections:
   a. Compare equipment nameplate data with the Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and clearances.
   d. Verify arresters are clean.
   e. Inspect bolted electrical connections for high resistance using:
      1) Low-resistance ohmmeter.
      2) Calibrated torque-wrench per manufacturer's published data or NETA.
   f. Verify each device's ground lead is individually attached to the ground bus or electrode.
2. Electrical Tests:
   a. Measure resistance of bolted connections with low-resistance ohmmeter.
   b. Perform insulation-resistance test on each arrester (phase terminal to ground), 1 minute; test voltage per manufacturer's published data or NETA.
   c. Test grounding connection per this specification.
3. Test Values – Visual and Mechanical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of the lowest value.
   b. Bolt-torque levels per manufacturer's published data or NETA.
4. Test Values – Electrical:
   a. Compare bolted-connection resistance to similar connections; investigate deviations greater than 50 percent of the lowest value.

b. Insulation-resistance values per manufacturer's published data or NETA; investigate below-minimum values.
c. Verify arrester-to-ground resistance is less than 0.5 ohms.

K. TRANSFER SWITCHES

1. Visual and Mechanical Inspection:
   a. Check doors and panels for proper interlocking.
   b. Check connections for high resistance by low-resistance ohmmeter calibrated torque wrench applied to bolted joints.
   c. Check positive mechanical and electrical interlock between normal and alternate sources.
   d. Automatic Transfer Switches:
      a) Check for proper operation: Manual transfer function switch.
      2) Verify settings and operation of control devices.
2. Electrical Tests:
   a. Insulation Resistance Tests:
      1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
      2) Phase-to-phase and phase-to-ground for 1 minute.
      3) Test values in accordance with manufacturer's published data.
   b. Contact Resistance Test:
      1) Contact resistance in microhms across each switch blade for both source positions.
      2) Investigate values exceeding 500 micro-ohms.
      3) Investigate values deviating from adjacent pole by more than 50 percent.
   c. Automatic Transfer Switches:
      1) Set and calibrate in accordance with specifications, manufacturer's recommendations, and information provided by Owner:
         a) Voltage and frequency sensing relays.
         b) Time delay relays.
      2) Perform automatic transfer tests by:
         a) Simulating loss of normal power.
         b) Return to normal power.
         c) Simulating loss of alternate power.
         d) Simulating single-phase conditions for normal and alternate sources.
      3) Monitor and verify operation and timing of:
         a) Normal and alternate voltage sensing relays.

b) Timing delay upon transfer and retransfer.
c) Interlocks and limit switch functions.

3.04 CLEANING

A. As specified in Section 16050, Common Work Results for Electrical.

3.05 PROTECTION

A. As specified in Section 16050, Common Work Results for Electrical.

END OF SECTION

SECTION 17050
BASIC MEASUREMENT AND CONTROL INSTRUMENTATION MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. This section includes general design, material, equipment fabrication, and documentation requirements for instrumentation and control systems.
2. Additional or more stringent requirements, when given in other sections, shall prevail.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): B16.5, Pipe Flanges and Flanged Fittings.
2. American National Standards Institute/American Petroleum Institute (ANSI/API):
   a. API RP550, Manual on Installation of Refinery Instruments and Control Systems.
   b. 551, Process Measurement Instrumentation.
3. ASTM International (ASTM): A269, Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
4. CWS Specifications:
   a. Section 01640, Manufacturers' Services and Training.
   b. Section 01756, Testing and Facility Startup.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16950, Field Electrical Acceptance Tests.
5. Instrumentation, Systems, and Automation Society (ISA):
   a. S5.1, Instrumentation Symbols and Identification.
   b. S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.
   c. S5.4, Instrument Loop Diagrams.
   d. S5.5, Graphic Symbols for Process Displays.
   e. RP7.1, Pneumatic Control Circuit Pressure Test.
   f. S7.3, Quality Standard for Instrument Air.

g. S12.4, Instrument Purging for Reduction of Hazardous Area Classification.
h. S18.1, Annunciator Sequences and Specifications.
i. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
j. S51.1, Process Instrumentation Terminology.
k. RP60.3, Human Engineering for Control Centers.
l. S71.04, Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts maximum).
7. National Fire Protection Association (NFPA):
   a. 70, National Electric Code (NEC).
   b. 496, Purged and Pressurized Enclosures for Electrical Equipment.
   c. 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
8. UL: 508, Industrial Control Equipment.

1.03 DEFINITIONS

A. Where a term is used in specification section number series 17000 through 17999 relating to instrumentation, and the meaning is not defined therein or elsewhere in the Contract Documents, the meaning of the term shall be as defined in ISA S51.1, Process Instrumentation Terminology, or if not contained in ISA 51.1, as defined in listed reference standards under Article References.

B. Control Circuit: Any circuit operating at 80V ac or 80V dc or more, whose principal purpose is the conveyance of information and not the conveyance of energy for the operation of an electrically powered device.

C. ORT-1 - Operational Readiness Testing, Part 1:

1. ORT-1 testing is a verification of circuit functionality based on circuit diagrams and loop drawings. Testing includes checkout from/to field instruments, local control stations, VFDs, Starter Buckets, MCCs, Vendor Panels, and Plant PLC. Testing activities includes the following:
   a. Wiring Terminations and Circuit Continuity.
   b. Conductor and Conduit Labels.
   c. Power and Control Circuits.
   d. Instrument Signals.
   e. PLC Signal Response Based on Process Value or Position at Field Device.

D. ORT-2 - Operational Readiness Testing, Part 2: Control System Software (PLC & HMI) is verified by the programmer as detailed in the Control Loop Descriptions.

E. PAT - Performance Acceptance Testing: Testing described in Section 01756, Testing and Facility Startup.

F. Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term “panel” in these Contract Documents shall be interpreted as a general term, which includes flat panels, enclosures, cabinets, and consoles.

G. Power Circuit: Any circuit operating at 80V (ac or dc) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.

H. PICS: Process Instrumentation and Control System.

I. SCADA: Supervisory Control and Data Acquisition.

J. Signal Circuit: Any circuit operating at less than 80V ac or 80V dc.

1.04 INSTRUMENTATION AND CONTROL SYSTEM DESCRIPTION

A. Overview:

1. New instrumentation and control for Digester 3 Process and associated upgrades.
2. Interface to existing PLC panels.
3. Extensions of plant PLC Ethernet networks.
4. Local Control Stations for process equipment.
5. Intrinsically-safe relay field panels.
6. Refer to Section 17101, Control Loop Descriptions, for Control Descriptions.

B. Work Includes:

1. Instrumentation and control works shall include, but not be limited to, field instrumentation and controls, field panels for control stations and intrinsically-safe relays, control panel work, testing, training, documentation, and related items.

2. The Contractor shall provide, through the services of a qualified Process Control and Instrumentation System (PICS) subcontractor, a complete and functioning control system. The PICS shall be responsible for all control work except as excluded in this paragraph. PLC and SCADA programming are to be provided by the Owner.
3. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
    a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, PLC inputs and outputs, etc.) before performing any Work.
    b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
    c. Documentation for modified panels shall be in the form of AutoCAD drawings. Markups of existing drawings are not acceptable. As-Built Drawings are available, however, CAD drawings for existing panels are not available.
        1) Only modified portions of modified panels are required to be documented.

C. Work by Others:

1. The Owner will provide PLC hardware and control panel terminal blocks. The Contractor shall coordinate all wiring assignments with Owner and land all field wiring at PLC panel terminals.
2. The Owner will provide network switches and patch panels. The Contractor shall route all network cables and terminate with connectors for plugging into equipment.
3. The Owner will provide application programming for the Plant PLCs and SCADA workstations. The Contractor shall, provide assistance with the onsite check out of application software provided by the Owner per Article Field Quality Control.
4. Subsequently, field testing of the revised control programs shall be performed per Article Field Quality Control.

1.05 DESIGN REQUIREMENTS

A. Review other sections and divisions of the Contract Documents for full compliance with the total Contract Documents. In the event of a conflict between sections, the Contractor shall promptly seek clarification from the Engineer.

B. Unless different requirements are clearly specified or shown elsewhere, instrumentation and control design, materials, equipment, installation, and testing shall comply with the requirements of the following specifications:

1. Division 11, Equipment.
2. Division 15, Mechanical.
3. Division 16, Electrical.
4. Division 17, Process Instrumentation and Controls.

C. Detailed Wiring Design:

1. Typical panel wiring diagrams, interconnecting wiring diagrams, and loop wiring diagrams are included on the Drawings and designed to completely show control panel wiring, terminations, interfaces with other systems, hardwire functions, interlocks, and wiring of components provided.
2. The Drawings contain typical wiring diagrams that apply to multiple circuit diagrams, such as loop drawings and control wiring diagrams. The Contractor shall create an individual drawing from each piece of equipment or instrument listed on the typical drawings and customize for each control circuit and loop.

D. Completeness:

1. Provide a complete and fully functional instrumentation and control system ready for use.
2. Components which are not identified on the Drawings and Specifications, but necessary to meet the full functional operation and performance requirements, shall be provided.
3. Equipment shall be designed and installed in full conformity with the Drawings, Specifications, and instructions and recommendations of the related equipment manufacturer.

E. Connections and Appurtenances:

1. The instrumentation and control systems shall include all necessary connections to sources of electrical power, air, water, drains, and vents, with all required valves, switches, and accessories as specified or as recommended for best operation by the manufacturer of the equipment furnished.
2. All necessary mounting panels, stands, hangers, and brackets shall be furnished and installed and shall comply with the relevant sections of these specifications.

F. Coordination:

1. Systems and equipment provided under this section shall be designed and coordinated for proper operation with related equipment and materials provided under other sections of these specifications, and where applicable, under other referenced contracts, and with identified existing equipment.
2. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the System Supplier, the other subcontractors or suppliers.

G. Control Functions: Control functions are provided in Section 17101, Control Loop Descriptions.

H. Instrument Tagging: Refer to Section 16075, Electrical Identification, for tagging requirements.

I. Hazardous (Classified) Areas:

1. Instrumentation and control equipment specified, is subject to the requirements for hazardous (classified) areas as specified in Division 16, Electrical, and indicated on the Drawings.
2. Two-wire transmitters to be installed in a hazardous (classified) area shall be Factory Mutual approved intrinsically safe, and made safe by means of suitably rated Factory Mutual approved intrinsically safe barriers installed in a non-hazardous area.
3. Switches to be installed in a hazardous (classified) area shall be made safe by means of suitably rated Factory Mutual approved intrinsically safe barriers or intrinsically safe relays installed in a nonhazardous area.

J. Equipment Locations:

1. The monitoring and control system configurations are diagrammatic. The locations of the equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interference and by the electrical terminations on the equipment.
2. Equipment shall be located and installed so that it is readily accessible for operations and maintenance but does not obstruct the removal of equipment.

K. Documentation to be provided:

1. All aspects of the instrumentation and control systems design shall be fully documented, and subsequently revised to conform to the "As-Built" installation.
2. The numbering of all instruments, equipment, terminal blocks, conductors, and cables shall be shown on all related documents.

L. Testing and Startup:

1. After installation of equipment and instrumentation is complete, testing shall be performed by the PICS contractor in a series of steps as described below and detailed in Section 01756, Testing and Facility Startup. Refer to Division 16, Electrical, specification for testing and verification requirements for electrical. Sections described in Section 01756, Testing and Facility Startup, include the following:
   a. Instrument calibrations.
   b. ORT-1.
   c. ORT-2.
   d. Performance Acceptance Testing (PAT).

1.06 SUBMITTALS

A. General:

1. Submit in accordance with Section 01330, Submittal Procedures.
2. Submittal data shall be grouped in a logical manner to facilitate review of subsystems and each submittal shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review.
3. Incomplete submittals will be returned to the Contractor without the Engineer's review and without Contract time extension.
4. Design Data submittals shall be reviewed and returned with resubmittal not required, before fabrication is started.
5. All panel drawings and loop drawings shall be produced with latest version of AutoCAD software.
6. Variations: A notice of variation shall be included in any submittal deviating from the Drawings or Specifications.
7. Hardware submittals shall be provided within 60 days of the Notice to Proceed.

B. Presubmittal Conference:

1. The Engineer shall arrange and conduct a Pre-submittal Conference within 60 days (number of days to be determined based on Project size) after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the Contractor intends to carry out its responsibilities for Shop Drawing submittal on the Work to be provided under this section. The Contractor and the Engineer shall attend. Both the Contractor and the Engineer may invite additional parties at their discretion.
2. The Contractor shall allot one, 4-hour half-day for the Conference.
3. The Contractor shall present the following for discussion at the Conference:
    a. A list of equipment and materials required for the PICS and the manufacturer's name and model number for each proposed item. See Section 01330, Submittal Procedures.
    b. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the Engineer.
    c. An exact one-to-one sample of each type of submittal herein, including control loop drawings as described in Project-Wide Wiring Drawing Submittal.
    d. A schedule developed in MS Excel or MS Project for all system related activities from the Pre-submittal Conference through startup and training. Dates of submittals, design, fabrication, programming (by others), factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.
    e. An overview of the proposed training plan. The Owner's staff and Engineer will review the overview and may request changes. All changes to the proposed training shall be resolved at the presubmittal conference. The overview shall include the following for each proposed course:
        1) Course title and objectives.
        2) Prerequisite training and experience of attendees.
        3) Course Content: A topical outline.
        4) Course duration.
        5) Course Format: Lecture, laboratory demonstration, etc.
4. The Engineer shall take minutes of the Conference, including all events, questions, and resolutions. Prior to adjournment, all parties must concur with the accuracy of the minutes and sign accordingly.

C. The system supplier shall submit wiring diagrams for approval by the Engineer and Owner at the following three stages:

1. Initial wiring diagrams shall be submitted 60 days after Notice to Proceed. The templates included in the Contract Documents will be used to document each and every loop on the Project. All control panel wiring and terminal block numbering shall be shown, including any power wiring. The diagrams at the initial stage are not required to include any non-PICS equipment terminal information or actual wiring numbers. After this submittal is approved satisfactorily the control panel fabrication can proceed.
2. Construction wiring diagrams shall be submitted 30 days after approval of initial wiring diagrams and the approval of all the equipment submittals that have connections to PICS equipment, including valve actuators, VFDs and vendor provided control panels. This set of wiring diagrams will be used throughout the construction phase of the Project and shall include all termination information for all equipment, including packaged equipment and all instruments provided for the Project. Each diagram will also include complete wiring numbers that comply with Article Installation, and as indicated on the instrument drawings. These diagrams do not include electrical power distribution system or HVAC systems, or the internal wiring of equipment such as valve actuators, VFD drives, or other equipment not supplied as part of the PICS. After this set of wiring diagrams have been approved by the Engineer they shall be used as a construction tool by the electrical subcontractor, system supplier, and the Contractor for field wiring, testing and startup activities. The system supplier shall be responsible for maintaining the diagrams throughout the construction phase of the Project by incorporating any “as-built” information and changes from the electrical subcontractor and Contractor as the construction phase progresses. These construction wiring diagrams may be submitted in subsets to better align with the actual construction sequence.
3. Preliminary field markup as-built wiring diagrams shall be submitted 5 days after all equipment has successfully completed the ORT-1, ORT-2, and performance tests. The wiring diagrams shall fully document any changes that have occurred during the construction phase of the Project. Final as-built wiring diagrams shall be submitted 30 days after all equipment has successfully completed the ORT-1, ORT-2, and performance testing.

D. Product Data:

1. General:
   a. Submitted for noncustom manufactured material listed in this and other sections and shown on the Shop Drawings.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these specifications.
   c. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
   d. Legibly cross out options that do not apply or equipment not intended to be supplied.
2. Material and Equipment Schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and instruments for this project.
   b. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
3. Instrument Data Sheets and Cut Sheets:
   a. Partially completed data sheets are provided at the end of each instrument specification. The Contractor shall use the Specifications and Drawings to complete the Instrument Data Sheets.
      1) The partially completed data sheets are not intended to be used as a takeoff list. The Contractor shall provide instruments as indicated in Project Specifications and on the Drawings.
   b. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hardcopy, for each instrument and component according to ISA S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. Include the following information on the data sheet:
      1) Component functional description used herein and on the Drawings.
      2) Manufacturers model number or other product designation.

3) Tag number used herein and on the Drawings.
4) System or loop of which the component is a part.
5) Location or assembly at which the component is to be installed.
6) Input and output characteristics.
7) Scale range with units and multiplier.
8) Requirements for electric supply.
9) Requirements for air supply.
10) Power consumption.
11) Response timing.
12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

c. Provide a technical brochure or bulletin (“cut sheet”) for each instrument on the Project. Submit with the corresponding data sheets:
1) Where the same make and model of instrument is used in two or more applications on the Project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
2) Include a list of tag numbers for which it applies with each brochure or bulletin.
3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
4) Cross out models, features, options, or accessories that are not being provided.
5) Clearly mark and identify special options and features.

4. Organization: Index the data sheets and brochures in the submittal by systems or loops.
5. Control Panel Hardware Submittal:
a. Submit the following in one submittal package.
b. Complete and detailed bills of materials:
1) A bill of material list, including quantity, description, manufacturer, part number, serial number, vendor name with phone and spare part list with unit price where required, shall be submitted for each of the PICS system

components. Bills of material shall include all items within an enclosure.

2) Provide the bill of material electronically in Microsoft Excel format.

c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and SCADA equipment.

d. Requirements for physical separation between control system components and 120V ac, 480V ac, and medium-voltage power cables.

e. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:

1) The manufacturer's model number or other identifying product designation.
2) Tag and loop number.
3) System to which it belongs.
4) Site to which it applies.
5) Input and output characteristics.
6) Requirements for electric power.
7) Requirements for air supply (if any).
8) Device ambient operating requirements.
9) Materials of construction.
10) Component functional description used in the Contract Documents.
11) Scale, range, units, and multiplier (if any).
12) Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air.
13) Special requirements or features.

E. Shop Drawings:

1. General:

a. Preparation of Shop Drawings shall not commence until adjournment of the Presubmittal Conference.

b. Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate Shop and Record Drawings:

1) Clearly show every wire, circuit, and terminal provided under this Contract on one or more submitted wiring diagrams.

c. Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters,

variable speed drives, control valves, flow meters, chemical feeders and other equipment related to the PICS.

d. Generate all drawings developed for this Project utilizing AutoCAD:
   1) Furnish electronically, as well as hard copies on 11-inch by 17-inch plain bond paper.
e. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
   1) Furnish the initial shop drawing submittal bound in one or more standard size, three-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
   2) Binder Ring Size: Not to exceed 3 inches.
f. Include the letterhead and/or title block of the firm responsible for the preparation of all the Shop Drawings. Include the following information in the title block, as a minimum:
   1) The firm's registered business name.
   2) Firm's physical address, email address, and phone number.
   3) Owner's name.
   4) Project name and location.
   5) Drawing name.
   6) Revision level.
   7) Personnel responsible for the content of the Drawing.
   8) Date.

2. Shop Drawing Requirements:
   a. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
   b. Locations of conduit entrances and access plates.
   c. Component layout and identification.
   d. Schematic and wiring diagrams with wire numbers and terminal identification.
   e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
   f. Anchoring method and leveling criteria, including manufacturer's recommendations for the seismic and wind conditions specified in Section 01612, Anchorage and Bracing.
   g. Weight.
   h. Finish.
   i. Nameplates: Refer to Section 16075, Electrical Identification.
   j. Temperature limitations, as applicable.
   k. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PICS shall be included in the Shop Drawing submittal.

3. The Contractor shall submit wiring diagrams for approval by the Engineer and Owner:
   a. Wiring diagrams shall be submitted 90 days after notice to proceed. The templates included in the Contract Documents will be used to document each and every loop on the project. All control panel wiring and terminal block numbering shall be shown, including any power wiring. After this submittal is approved satisfactorily the control panel fabrication can proceed.
   b. Preliminary field mark-up as-built wiring diagrams shall be submitted 5 days after all equipment has successfully completed the ORT-1, ORT-2, and Performance Tests. The wiring diagrams shall fully document any changes that have occurred during the construction phase of the project. Final as-built wiring diagrams shall be submitted 30 days after all equipment has successfully completed the ORT-1, ORT-2, and Performance Testing.
4. Itemized instrument summary. The summary shall be prepared with Microsoft Excel software and shall be submitted on hard copy. The instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:
   a. Tag number.
   b. Manufacturer.
   c. Model number.
   d. Service.
   e. Area location.
   f. Calibrated range.
   g. Loop drawing number.
   h. Associated LCP and PLC.
5. Instrument Installation Drawings:
   a. Submit instrument installation, mounting, and anchoring details for all components and assemblies in an electronic AutoCAD and hard copy format, including access requirements and conduit connection or entry details.
   b. Furnish for each instrument a dedicated 8-1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
   c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer’s recommendations and is fully warrantable.
   d. For each detail, provide, as a minimum, the following contents:
      1) Necessary sections and elevation views required to define instrument location by referencing tank, building or

equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.

2) Ambient temperature and humidity where the instrument is to be installed.
3) Corrosive qualities of the environment where the instrument is to be installed.
4) Hazardous rating of the environment where the instrument is to be installed.
5) Process line pipe or tank size, service, and material.
6) Process tap elevation and location.
7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
8) Routing of tubing and identification of supports.
9) Mounting brackets, stands, anchoring devices, and sun shades.
10) Conduit entry size, number, location, and delineation between power and signal.
11) NEMA ratings of enclosures and all components.
12) Clearances required for instrument servicing.
13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

6. Control Panel Drawings:
   a. Layout Drawings:
      1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
      2) As a minimum, include the following information:
         a) To scale front, side, and plan views.
         b) Dimensions.
         c) Interior and exterior arrangements.
         d) Mounting information, including conduit entrance location.
         e) Finish data.
         f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
         g) Nameplate legend including text, letter size, and colors.
   b. Wiring and Piping Diagrams:
      1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
      2) Include the following information:
         a) Name of panel.
         b) Wiring and piping sizes and types.

c) Terminal strip numbers.
d) Wire tags and labels.
e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
f) Electrical control schematics in accordance with ANSI standards.

c. Installation Drawings:
1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
2) Provide scaled drawings and show the position of the equipment at its intended installation location.
3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

7. Control System Diagram:
a. Submit a complete set of control system diagrams including the following information:
1) All PLCs, workstations, printers, communication devices, and communication links:
a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
(1) All cables required for communication requirements.
(2) Show each component fully annotated with conduit size and number associated with the power source.

F. Testing and Startup Plan Submittal: Refer to Section 01756, Testing and Facility Startup, for Testing and Startup Plan Submittal requirements.

G. Technical Manuals/Operation and Maintenance Manuals:

1. Manuals shall be based upon the approved Shop Drawing submittals as modified for the conditions encountered in the field.
2. Furnish the Engineer with a complete preliminary set of written Operation and Maintenance Manuals 8 weeks before calibration, startup, and/or testing.
3. Furnish in accordance with Section 01782, Operation and Maintenance Data, and the following additional requirements.

4. Submit preliminary sets of these manuals to the Engineer for review of format and content:
    a. Engineer will return one set with comments.
    b. Revise and/or amended as required and submit the requisite number of copies to the Engineer 15 days before Precommissioning of the systems.
5. Incorporate changes that occur during startup and submit as part of the final manuals.
6. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
7. Include Record Documents and the approved Shop Drawing submittals, modified for conditions encountered in the field during the Work.
8. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, and time delays), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
9. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
10. Spare Parts List:
    a. Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
        1) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
    b. Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
    c. Provide the name, address, and phone number of manufacturer and manufacturer’s local service representative of these parts.
11. Include signed and completed calibration sheets, ORT-1 forms, and Performance Acceptance Testing form.

H. Training Submittals: The Training Submittal shall be based on the preliminary submittal provided at the Presubmittal Conference.

1. Refer to Section 01640, Manufacturers’ Services and Training, for Training Submittal requirements.

I. Record Documents:

1. Furnish in accordance with Section 01770, Closeout Procedures.
2. Provide record documents of all instrumentation drawings.

3. Record Drawing Requirements:
    a. Submit final fully updated Record Drawings upon completion of the Work for final review.
    b. Clearly and neatly show all changes in accordance with Section 01770, Closeout Procedures, and the following:
        1) All existing pipe, conduit, wire, instruments, or other structures encountered or uncovered during construction.
4. Shop Drawings:
    a. Upon completion of the Work, update all Shop Drawings to indicate the final as-built configuration of the systems:
        1) Should an error be found in a Shop Drawing during installation or startup of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
        2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
    b. Provide “As-Built” Shop Drawings for all instrumentation equipment on 11-inch by 17-inch paper.
        1) Provide actual field markups (redlines) upon Substantial Completion.
    c. Provide electronic copies of these documents in latest AutoCAD version and Portable Document Format (*.pdf). Size all Drawings to be readable and legible on 11-inch by 17-inch media.
5. Submittal Documents:
    a. Provide an interim submittal of Record Documents after the PICS system Pre-commissioning.
    b. Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01770, Closeout Procedures, or the General Requirements.
6. Review and Corrections:
    a. Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
    b. Promptly correct and re-submit Record Documents returned for correction.

J. Project Closeout Submittals:

1. Recommended Spare Parts List.
2. Operation and Maintenance Manuals for Project, fully indexed, incorporating all instrumentation and control system documentation submitted and produced, and revised to conform to the “As-Built” installation. Application specific operation and maintenance instruction

and application program records shall be included. Submit one set for review and four sets of the final accepted manuals.

3. Submit reproducible Drawings revised to conform to “As-Built” installation for the Owner’s records after acceptance of the Project Operation and Maintenance Manuals.
4. Electronic files, two sets, bearing all electronically formatted documents including “As-Built” CAD Drawings and application programs, shall be submitted for information only and the Owner’s records, after acceptance of Operation and Maintenance Manuals for Project. The media shall contain a table of contents, ASCII formatted, identifying the contents of each file and the software program/version with which it was produced. The media shall contain a CAD plotting document providing definition of, and correlation between layers/colors and line types for all CAD files. A pdf file of each CAD drawing shall also be provided.
5. “As-Built” Wiring Diagrams Submittals: Final “As-Built” set of wiring diagrams with Contractor, Division 16, Electrical, and PICS supplier coordination signature that each suppler has completed all “As-Built” markups to every detailed wiring diagram in the construction set of wiring diagrams.

1.07 QUALITY ASSURANCE

A. Procurement Restriction: Certain equipment manufacturers with marketing operations based on local agents, have terms where the selling agent has responsibility for after sales service. In such cases, the Contractor’s procurement of such equipment is restricted to the selling agent within whose service area the equipment will be finally installed, thus assuring the Owner of the availability of local after sales service.

B. Quality Assurance Procedure:

1. A quality assurance procedure shall be defined and implemented by the Contractor supervising instrumentation and control systems. The procedure shall:
   a. Require that the Project Manager schedule and budget for in-house and inter-Contractor checking.
   b. Specify qualifications required for engineering and technical personnel in the execution and checking of specific tasks.
   c. Identify the responsibilities of the executor and the checker.
   d. Provide quality assurance data sheets listing specific tasks and stages of tasks, with space for the printed names of the executor and checker, and the checker’s signature and date.

2. The quality assurance procedure shall form part of the contractual requirements for subcontractors, and manufacturers or suppliers with unit responsibility.
3. The quality assurance data sheets shall be maintained current and shall be available for inspection upon request.

C. Substitutes and “Or-Equals”:

1. Substitutes and “Or-Equals” may be proposed in accordance with the General Conditions.
2. Where manufacturers of instrumentation or control system products other than those specified are proposed, they shall have a minimum of 5 years’ experience in the manufacture of comparable equipment used in similar applications. The Contractor shall provide manufacturers’ references to existing installations upon request of the Engineer. Noncompliance shall be a basis for rejection.

D. Coordination Meetings:

1. General: In accordance with Section 01110, Summary of Work.
   a. Attendees may Include: Engineer, Owner, Contractor, and PICS Subcontractor.
   b. First Meeting: Schedule per the requirements of Section 01110, Summary of Work. Thereafter, monthly, prior to first startup activity and weekly during startup activities. Include meetings on progress schedule.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.
2. Store all equipment and materials delivered to the Job Site in a location that will not interfere with the construction or the Owner’s operations.

B. Delivery Timing: No instrumentation or control system equipment shall be delivered to the Job Site until required for integration with other construction, and all necessary environmental preparations have been made.

C. Intermediate Storage and Handling:

1. When the Contractor is obliged to take delivery in advance of this time, the Contractor shall do so at a bonded air-conditioned warehouse.
2. The Contractor shall provide for storage at the warehouse and transport of the equipment to the Job Site by suitably qualified movers with moving equipment (e.g., floating bed truck) as recommended by the manufacturer.

D. Noncompliance:

1. Should the equipment be delivered to the Job Site and be stored in adverse conditions or installed in improper environmental conditions, then at the Engineer's discretion, prior testing may be declared void.
2. The prior testing (e.g., factory acceptance testing) shall be repeated and/or, at the discretion of the Engineer, a reduced value dollar credit shall be provided by the Contractor.
3. The equipment shall still be required to satisfy site testing performance criteria.

1.09 SITE CONDITIONS

A. General: Instrumentation and control systems equipment shall be suitable, or made suitable, for site conditions at the Project location.

B. Temperature:

1. Electrical and Control Room Temperature: 60 degrees F to 100 degrees F.
2. Field Locations Temperature: 20 degrees F to 120 degrees F.
3. Above temperatures do not include effects of direct sunlight or wind chill.

C. Relative Humidity (RH):

1. Electrical and Control Rooms RH: 20 percent to 80 percent.
2. Field Locations RH: 10 percent to 100 percent.

D. Atmospheric Contaminants:

1. Atmospheric contaminants include hydrogen-sulfide, chlorine, ammonia, and dust in indeterminate concentrations.
2. Corrosive atmosphere testing shall be conducted, where specified.

E. Electromagnetic Radiation:

1. Electromagnetic Radiation:
   a. 27 MHz to 500 MHz: 10 volts/m.

PART 2 PRODUCTS

2.01 MATERIALS

A. Refer to other instrumentation and control sections.

2.02 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Tests shall be observed by the Owner. Tests may be observed by the Electrical Engineer and the Project Engineer.
2. The Owner shall bear costs associated with travel for this test including, but not limited to, lodging, meals, travel time, time to witness tests, etc., for up to three representatives of the Owner.
3. Costs associated with accommodation of the witness testing at the testing facility shall be paid for by Contractor.
4. The Engineer shall be reimbursed by the Owner for all costs associated with these tests.
5. Prerequisites to Factory Testing:
   a. Approved test plan.
   b. Notice to the Owner given 21 working days prior to the start of testing.
6. Instrumentation and control systems shall be factory tested and calibrated.
7. Factory test/calibration records shall be submitted to the Engineer to show that the equipment has achieved the specified performance and accuracy.
8. Additional Factory Testing: Refer to other instrumentation and control sections.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install instrumentation and control systems in accordance with the Drawings and Specifications, final submittals, manufacturer’s instructions, and (where applicable) American Petroleum Institute RP550/551.

B. Electrical: Install cable and wiring in accordance with applicable sections in Division 16, Electrical.

C. Piping: Install piping and fittings in accordance with applicable sections of Division 05, Metals, and Division 15, Mechanical.

D. Wiring Identification Numbers:

1. Each wire shall be labeled per the Clean Water Services standards as demonstrated on the example wiring diagrams provided as part of the Drawings and as summarized below:
    a. Cable numbers shall be named based on the equipment tag of the field device utilizing the electrical power source. The form of the tag shall be 406P1205C2 where '406P1205' represents the equipment designation; 'C' indicated a control cable and 2 is a sequential number developed as part of the circuit design. Cable type designations shall follow the designations listed below:
        1) C – Control.
        2) S – Signal (below 80V ac or 80V dc).
        3) P – Power.
        4) N – Network (Ethernet, and Profibus).
        5) Examples for Cable Numbers:
            a) Signal cable from Control Valve (406LCV1205) to PLC terminals:
                (1) Input Twisted Shielded Pair: 406FCV1205S1+ and 406FCV1205S1-.
                (2) Feedback Twisted Shielded Pair:
                    (a) 406FCV1205S2+ and 406FCV1205S2-.
                    (b) Control cable to "Open" and "Closed" limit switches on control valve.
            b) Power from PLC: 406ZSO1206C1.
                (1) Return from ZSO: 406ZSO1206C2.
                (2) Return from ZSC: 406ZSC1206C1.
    b. Within PLC cabinets, PLC control and signal wiring from/to I/O cards and PLC terminal strips shall be labeled based on the rack, slot, and point number of the I/O point. Labels shall take one of the following forms:
        1) RXSYPZ - Discrete PLC I/O Wiring.
        2) RXSYPZ+/- - Analog PLC I/O Wiring.
        3) AC - Power Connection:
            a) Where X is replaced with the PLC rack of the I/O point.

b) Where Y is replaced with the slot of the rack the I/O point is located.
c) Where Z is replaced with the point number of the slot I/O point is located.

E. Ancillary Devices: The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing the Work. Such changes shall not be a basis of claims for extra work or delay.

3.02 FIELD QUALITY CONTROL

A. Operational Readiness Testing:

1. Operational Readiness Tests, ORT-1 and ORT-2, shall be performed as described in Section 01756, Testing and Facility Startup.
   a. ORT forms are located in the supplemental Section 01756, Testing and Facility Startup.

B. Performance Acceptance Tests (PAT): These are the activities that Section 01756, Testing and Facility Startup, refers to as performance testing.

C. Specialty Equipment: For certain components or systems provided under this section but not manufactured by PICS Subcontractor, provide services of qualified manufacturer's representative during installation, startup, demonstration testing, and Owner training.

3.03 TRAINING

A. Onsite Training: Training shall be performed as described in Section 01640, Manufacturers' Services and Training.

3.04 CLEANING

A. Clean area during construction and after completion of construction.

B. Vacuum panels, cabinets, and enclosures to remove dust and debris. Wipe surfaces clean.

END OF SECTION

SECTION 17101
CONTROL LOOP DESCRIPTIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes control loop descriptions for the processes associated with this Project.

1.02 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Control Loop Descriptions:
   a. DC 1 and DC 2 Waste Gas Burner Flow Control.
   b. FOG Waste Storage and Feed.
   c. DC2 Digester Sludge Recirculation Sludge Grinders.
   d. DC2 Digester Sludge Recirculation Pumps.
   e. DC 2 Digesters Temperature Control.
   f. Heating Water Boilers.
   g. Hot Water Pumps and Heat Loop.
   h. Secondary Heat Loop Pumps.
   i. Digesters 1, 2, and 3 Mixers.
   j. Digester Feed Pumping.
   k. Digested Sludge Pumps.
   l. Digester Complex 2 Digester Feed Valves.
   m. DC 2 Control Room Air Handling Unit.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

Control Loop Description	Digester Complex 1 and 2 Waste Gas Burner Flow Control (D60_135_CTL_045, D60_135_CTL_032)

Process Description:

There are two waste gas burners (WGB) that flare digester gas in excess of the quantity consumed by the Cogen engines and Boilers 1 and 2. One WGB is located at Digester Complex 1 (DC1) and the other is located at Digester Complex 2 (DC2). Digester gas pressure is monitored at the digesters and digester gas is conveyed to each of the WGBs through an interconnecting digester gas (DG) header. At each WGB, the DG header is split into two parallel lines. For low production events, the mechanical pressure relief valve in the primary line opens at its primary pressure setpoint sending digester gas to the waste gas burner. For high demand events, digester gas pressure may continue to rise despite the mechanical relief valve adjusted to its lowest position. For these high production events, the flow control valves in the secondary (bypass) line will be controlled by the plant PLC to proportionally control the digester gas pressure. The valves will start to open at 14-inch WC and will be fully open at 15.5-inch WC. A flow meter at each WGB is provided to totalize the volume of gas flared at each WGB.

Under normal operation, both WGBs are in service managing the digester gas pressure with the mechanical pressure relief valves. However, the DC2 WGB is used to manage high demand events, with the DC1 WGB providing standby capacity if the DC2 WGB is out of service due to a fault or maintenance.

Digester gas WGB control panels, digester gas flow transmitters, and digester gas flow valves are fed from an UPS source to enable their operation during utility outages.

Reference Drawing(s):	008-I-001		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
740BNR6904	DC1 Waste Gas Burner	
740LCP6904	DC1 Waste Gas Burner Local Control Panel	
740CS6904	DC1 Waste Gas Burner Spark Generator Panel	
740FCV6904	DC1 Waste Gas Burner Flow Control Bypass Valve	
20M30201	DC2 Waste Gas Burner	
20LCP30201	DC2 Waste Gas Burner Local Control Panel	
20LCP30202	DC2 Waste Gas Burner Spark Generator Panel	
725FCV6901	DC2 Waste Gas Burner Flow Control Bypass Valve	

Instrumentation:

Tag No.	Description	Notes
740FIT6904	DC1 Waste Gas Burner Flow Transmitter	0-1200 scfm
20FIT30301	DC2 Waste Gas Burner Flow Transmitter	
20PSH30301	DC2 Waste Gas Burner Pressure Switch High	
20PIT10401	DC2 Digester 1 Gas Pressure Transmitter	
20PIT10402	DC2 Digester 2 Gas Pressure Transmitter	
725PIT6903	DC2 Digester 3 Digester Gas Pressure Transmitter	
PIT10111	DC1 Digester Gas Pressure	

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

None.

Motor Control Center

None.

MFR Control Center

For each Waste Gas Burner:

- Self-contained unit that comes equipped with the manufacturer furnished local control panel.
- In AUTO mode, the burner only uses digester gas when signaled from the PLC that digester gas will be available as fuel; otherwise, it is off (no pilot).
- With the POWER OFF/ON selector switch in the POWER ON position, 120 volts AC is provided to the pilot controller.
    - With the pilot controller's STANDBY/AUTO/MANUAL selector switch in STANDBY, the controller will not attempt to light pilot regardless of digester gas system pressure.
    - AUTO is the normal operating position.
        - With the switch in AUTO, pilot ignition cycle starts when digester system pressure increases to 10.5-inch WC.
        - The Waste Gas Burner will flare digester gas when the pressure in the digesters reaches the primary setpoint (12 inch WC, operator adjustable). The pressure relief valve opens and digester gas flows through the primary line to DC1 and DC2 Waste Gas Burners.
    - MANUAL position permits the operator to manually light the pilot. By pushing the MANUAL IGNITER switch at the Local Control Station, the operator will start a spark igniter.

Local Control Station
For each Waste Gas Burner: • The waste gas burner can be operated locally only. No control is possible from SCADA. • The Thermocouple Control 1 ENABLE/DISABLE enables the thermocouple to sense pilot ON/OFF status. A red LED ON at the Local Control Station signifies that the unit is ENABLED. • A remote start simulator switch (RSSS) at the Local Control Station has two positions: o In ON, a high-pressure condition is simulated in the digester gas system, which starts the pilot controller's pilot lighting sequence. o In OFF, the pilot ignition is controlled by the digester gas system. The pilot controller will start the pilot lighting sequence if activated by the digester gas high pressure switch.
SCADA Control Operation and Alarm Reset
SCADA Manual
None.
SCADA Auto
• The Waste Gas Burner flow valves are setup as LEAD/STANDBY. When in AUTO, the duty Waste Gas Burner flow valve (DC2 WGB flow valve 725FV6901 or DC1 WGB flow valve 740FCV6904) is automatically controlled to relieve over-pressurization of the digester gas system by opening the WGB flow valve proportionally in response to the digester gas pressure, at 15.5-inch WC the valve will be 100% open. In normal conditions, the WGB flow valve is fully closed (4 mA position command from SCADA). • DC2 Digesters 1, 2, 3 and DC1 gas pressure are sensed by pressure transmitters 20PIT10401, 20PIT10402, 725PIT6903, and PIT10111 respectively. If the pressure in either digester reaches or exceeds the bypass setpoint, 14 in WC, the waste gas burner flow valve begins to open. The waste gas burner flow valve will proportionally open in response to the digester gas pressure, at 15.5-inch WC the valve will fully open to 100%. Once the digester gas pressure drops below 14-inch WC the bypass valve will fully close.

SCADA Display
Status and Process Display
• DC1 Waste Gas Burner ON. • DC1 Waste Gas Burner FAULT. • DC2 Waste Gas Burner ON. • DC2 Waste Gas Burner FAULT. • Digester 1 Digester Gas Pressure. • Digester 2 Digester Gas Pressure. • Digester 3 Digester Gas Pressure. • Digester Gas Flow to DC1 Waste Gas Burner. • Digester Gas Flow to DC2 Waste Gas Burner. • DC1 Waste Gas Burner Flow Valve Position Command. • DC1 Waste Gas Burner Flow Valve Position Feedback. • DC2 Waste Gas Burner Flow Valve Position Command. • DC2 Waste Gas Burner Flow Valve Position Feedback.
Operator Entries
• DC1 Waste Gas Burner Secondary Line Pressure Setpoint (Flow Valve Initial Position) • DC2 Waste Gas Burner Secondary Line Pressure Setpoint (Flow Valve Initial Position) • Waste Gas Burner Flow Valve Lead/Standby Selector.
SCADA Alarms and Resets
• DC2 Natural Gas Padding in Use. • Digester Gas Flow to DC1 Waste Gas Burner Flow Transmitter Fault (out of range). • Digester Gas Flow to DC2 Waste Gas Burner Flow Transmitter Fault (out of range). • Digester 1 Digester Gas Pressure Fault (out of range) • Digester 2 Digester Gas Pressure Fault (out of range) • Digester 3 Digester Gas Pressure Fault (out of range) • DC1 Waste Gas Burner Flow Valve Fail (position feedback out of tolerance by 5%). • DC1 Waste Gas Burner Fault. • DC1 Waste Gas Burner UPS Fault. • DC2 Waste Gas Burner Flow Valve Fail (position feedback out of tolerance by 5%). • DC2 Waste Gas Burner Fault. • DC2 Waste Gas Burner UPS Fault.

Hard-Wired Interlocks

- Upon loss of utility power, the PLC will no longer be energized and the 4-20 mA position command signal to each of the flow valve will no longer be provided. The flow valve actuator is configured to adjust to a "fail-safe" open position of 100% on loss of position command signal to prevent over-pressurization due to shutdown of digester gas consuming equipment on loss of utility power.
- Upon loss of utility power, the UPS will be supplying loads from battery power. "On Battery Power" relay output from UPS is hardwired to a dry contact override input at the flow valve to drive the flow valve to a fully open position.
- The pilot is to be ON whenever the bypass valve is not fully closed. Accordingly, fully closed relay output from flow valve is hardwired in parallel with digester gas pressure switch 20PSH30201 (DC2 WGB only) to the remote start contacts at the waste gas burner local control panels 20LCP30201 and 740LCP6904.

Software Interlocks

- Interlock signal for alarm when digester gas pressure falls below 3 inches water column causing pressure relief valves 20PRV30201 and 20PRV30202 to open for natural gas padding of Digesters 1, 2, and 3.
- Interlock signal for alarm when digester gas pressure falls below a predetermined setpoint (initially set at 7 inches water column) causing Boilers 1 and 2 fuel valves to switch to natural gas fuel.

Historical Trending and Run-Time Counters

- Digester Gas Flow to DC1 Waste Gas Burner.
- Digester Gas Flow to DC2 Waste Gas Burner.
- DC2 Digester 1 Digester Gas Pressure.
- DC2 Digester 2 Digester Gas Pressure.
- DC2 Digester 3 Digester Gas Pressure.
- DC1 Digester Gas Pressure.
- DC1 Waste Gas Burner Flow Valve Position.
- DC2 Waste Gas Burner Flow Valve Position.

Equipment Failure Sequence

None.

Equipment Automatic Failover Sequence

None.

Equipment (Auto/Manual) Restart After Power Interruption

None.

END OF SUPPLEMENT

Control Loop Description	FOG Waste Storage and Feed (D60_110_CTL_100)

Process Description:

FOG is stored in two 30,000-gallon stainless steel cone bottom tanks. In normal operations, inter-tank isolation valve 715FV6413 is open such that the tanks are hydraulically coupled. When a tank is taken out of service for maintenance or access, 715FV6413 is closed.

Tank level is measured, and FOG Waste Transfer Pumps and FOG Feed Pumps are shut off when associated tank level falls below the minimum low-liquid level.

Vents from the tanks are routed to a passive odor control system. This system contains two passive activated carbon vessels, one per tank, located on the backside of the building.

FOG feed to the digesters is provided by variable speed progressing cavity pumps with a range of approximately 5 gpm to 50 gpm. Flow rate setpoint is entered by operator based on managing FOG inventory and digester gas production. An operator-initiated flushing system using heated plant non-potable water is available to periodically clean the digester FOG feed pipes.

A dedicated FOG feed pipe is routed from each FOG feed pump to each digester with one spare FOG feed pipe.

Three FOG feed flow meters are located in the lower level of Digester Complex 2 (DC2), one for each FOG feed to digester.

There are two SCADA AUTO modes: SCADA AUTO – FLOW and SCADA AUTO – BUBBLE.

SCADA AUTO – FLOW:
Each digester is fed FOG continuously and flowrate is a simple operator set point. Care should be taken when selecting a set point to prevent overloading of FOG into the digesters and to ration FOG so it does not run out before the next delivery. Flowrates are usually between 5 gpm and 10 gpm.

SCADA AUTO – BUBBLE:
The digester FOG flowrate is adjusted based on a direct feedback loop. The system will look at the digester gas bubble storage and adjust the flowrate up or down as necessary to maintain 85% to 90% full. This will help maximize gas production as the engines will be running at full capacity and flaring will be unnecessary. When a FOG tank level reaches a designated low level (operator adjustable), the FOG feed rate will be dropped to a designated low flowrate to ensure that there is enough FOG until the next delivery. Initially this is set to be XX gallons to be consumed over XX days. The digesters remain more stable when FOG is delivered consistently.

Materials of construction and instrumentation are capable of operating at elevated temperatures up to 150 degrees F.

FOG volume below EL171.50 of FOG storage tanks are not accessible by the feed pumps due to suction connection to tank. Top of cone EL 171.00. Top of tank EL 190.00.

Reference Drawing(s):	008-I-009A		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
715T6411	FOG Waste Receiving Tank 1	30,000 gallons
715T6412	FOG Waste Receiving Tank 1	30,000 gallons
715P6402	FOG Feed Pump 1	2 - 50 gpm
715P6404	FOG Feed Pump 2	2 - 50 gpm
715P6406	FOG Feed Pump 3	2 - 50 gpm
740T6901	Digester Gas Holder	
715FV6413	Inter-Tank Connection Valve	

Instrumentation:

Tag No.	Description	Notes
715LIT6401	FOG Waste Receiving Tank 1 Level Transmitter	0 - 19 feet, Radar
715PSH6402	FOG Waste Feed Pump 1 Discharge Pressure Switch	50 psig
715TSH6402	FOG Waste Feed Pump 1 Stator Temperature Switch	
715FIT6402	FOG Waste Feed Pump 1 Discharge Flow Meter	0 - 50 gpm, Ultrasonic
715LIT6402	FOG Waste Receiving Tank 2 Level Transmitter	0 - 19 feet, Radar
715PSH6404	FOG Waste Feed Pump 2 Discharge Pressure Switch	50 psig
715TSH6404	FOG Waste Feed Pump 2 Stator Temperature Switch	
715FIT6404	FOG Waste Feed Pump 2 Discharge Flow Meter	0 - 50 gpm, Ultrasonic
715PSH6406	FOG Waste Feed Pump 3 Discharge Pressure Switch	50 psig
715TSH6406	FOG Waste Feed Pump 3 Stator Temperature Switch	
725FIT6401	FOG Waste Feed Pump 3 Discharge Flow Meter	0 - 50 gpm, Ultrasonic
740LIT6901	Gas Storage Holder Gas Level Transmitter	0-100%

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

For FOG feed pumps:

• MCC mounted VFD. A panel-mounted keypad for the VFD is provided for indication and programming only. The following functions are located on the VFD keypad: o Local light. o Remote light. o Fault light. o Reset button. o Start button. o Stop button. o Local/Remote button. o Run status.
Motor Control Center
None.
MFR Control Center
None.
Local Control Station
For FOG Feed Pumps: • LOCAL-OFF/RESET-REMOTE selector switch. • START and STOP pushbuttons for LOCAL control. • REMOTE control from SCADA. • HIGH PRESSURE light. • HIGH TEMPERATURE light.
SCADA Control Operation and Alarm Reset
SCADA Manual
For each FOG Feed Pump: • Place the equipment LOCAL-REMOTE selector in REMOTE. • Place the MANUAL-AUTO selector at the HMI graphics in MANUAL. • Press the HMI START button to start the equipment. • Press the HMI STOP button to stop the equipment.

SCADA Auto

Flow mode:

- The FOG Feed Pumps operate continuously. FOG Feed pump speed is controlled to maintain an operator-entered flow setpoint.
- Stop pump if associated tank is below low-low level shutoff.
    - Tank 1: EL171.875.
    - Tank 2: EL171.875.

Bubble Mode:

- The FOG Feed Pumps operate continuously. A direct feedback loop will increase or decrease the FOG pump speed to keep the gas bubble 85% to 90%.
- There is a tank level setpoint for minimum flow. When the FOG tanks reach this point, they will revert to the low flow setpoint to conserve FOG.
    - Typical low flow setpoint will be 5 gpm.
    - Typical low tank level setpoint for low flow will be EL171.875.
- Stop pump if associated tank is below low-low level shutoff.
    - Tank 1 EL171.875.
    - Tank 2 EL171.875.

SCADA Display

Status and Process Display

- For each FOG Feed Pump:
    - ON status.
    - REMOTE mode.
    - Speed.
    - Flow rate and total.
- Inter-Tank Valve:
    - OPEN
    - CLOSED
- Digester feed flow, GT 3 and 4 underflow pump speed, flow rate and sum of gas use (engine 1 and 2, flare 1 and 2 and boilers 1 and 2).

Operator Entries

- For each FOG Feed Pump:
    - SCADA MANUAL/AUTO selection.
    - MANUAL START/STOP control.
- BUBBLE or FLOW mode selection:
    - For each pump:
        - FOG Feed flow setpoint. (FLOW mode).
        - FOG max/min flowrate (BUBBLE mode).
        - Controlling level transmitter selection (reflects manual valve setup for pump suction)
- For each Tank:
    - Tank level setpoint for minimum flow (BUBBLE mode).

SCADA Alarms and Resets

• For each FOG Feed Pump:
  o FAIL alarm.
  o FAIL to Start and FAIL to Stop alarms.
  ▪ LOW flow when the flow is less than 2 gpm for 60 seconds while the pump is running.
  o HIGH discharge pressure.
  o HIGH stator temperature.
  o FOG Tank Low Level.

Hard-Wired Interlocks

• Shutdown interlocks for each FOG Feed Pump:
  o Pump Stator Temperature HIGH.
  o Pump Discharge Pressure HIGH.

Software Interlocks
• Interlock each Pump with LOW-LOW level in associated Tank (EL171.875); stop Pump below LOW-LOW level. • Interlock each Pump with READY signal from DC2.
Historical Trending and Run-time Counters

• For each Tank:
  o Level.
• For each FOG Feed Pump:
  o Flow rate.
  o Pump Speed.
• Quick trend:
  o Gas Bubble Level.
  o FOG Flow.
• Run Time for each Pump.

Equipment Failure Sequence
None.
Equipment Automatic Failover Sequence
None.
Equipment (Auto/Manual) Restart After Power Interruption
None.

END OF SUPPLEMENT

Control Loop Description	DC2 Digester Sludge Recirculation Sludge Grinders (D60_110_CTL_010)

Process Description:

Inline grinders are located on the suction side of the digester sludge recirculation pumps and heat exchangers. The grinders run continuously when the sludge recirculation pumps are on to break down large solids like rags, plastics, and other debris to protect downstream equipment such as the sludge heat exchangers from clogging.

Reference Drawing(s):	008-I-010A, 008-I-010B		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20M10101	Sludge Recirculation Pump Sludge Grinder 1	Manufacturer's LCP
20M10102	Sludge Recirculation Pump Sludge Grinder 2	Manufacturer's LCP
725GDR6703	Sludge Recirculation Pump Sludge Grinder 3	VFD
725GDR6704	Sludge Recirculation Pump Sludge Grinder 4	VFD
725GDR6706	Sludge Recirculation Pump Sludge Grinder 6	VFD

Instrumentation:

Tag No.	Description	Notes

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

For Grinders 3, 4, and 6:

- A VFD cabinet housing power and controls for operating the grinder motor. Operator adjustments are though pilot devices mounted on the panel door. A panel-mounted keypad for the VFD is provided for indication and programming only. The following functions are located on the VFD control panel door:
  - Manual speed pot.
  - Forward running light.
  - Reverse running light.
  - Power on light.
  - Fault light.
  - Reset button.

Motor Control Center
None.
MFR Control Center
None.
Local Control Station

For Grinders 1 and 2:

- A Manufacturer furnished local control panel at each grinder has:
  - A LOCAL-OFF/RESET-REMOTE selector switch
  - START FORWARD and START REVERSE pushbuttons.
  - STOP pushbutton.
- Indicator lights for:
  - Power ON.
  - Motor Running Forward.
  - Motor Running Reverse.
  - Motor Off.
- FAIL alarm for:
  - Motor Overload.
  - Grinder Overload / Fail.
  - Preventative Maintenance Required.
  - Full Service Required.

For Grinders 1 and 2:

- When **LOCAL** mode is chosen at the Local Control Station, the grinder can be started or stopped via pushbuttons at the Local Control Station. If the grinder encounters a jam or overload condition, it will stop and reverse direction to clear the obstruction. If the jam is cleared, the grinder will return to normal operation. If the jam condition still exists, the grinder will go through two additional reversing cycles within 30 seconds (3 times total) before signaling a grinder overload condition. On a grinder FAIL alarm, the grinder will shut off and prevent operation of the feed pump.
- The grinder can be run in reverse by pressing and HOLDING the REVERSE pushbutton.
- Pressing the STOP button stops the pump and RESETS FAULT circuit if grinder trips out on obstruction.

For Grinders 3, 4, and 6:

- At each Local Control Station:
  - Selector switch with LOCAL, OFF/RESET, REMOTE selections.
  - Selector switch with FORWARD, OFF, REVERSE selections.
  - Forward running light.
  - Reverse running light.

SCADA Control Operation and Alarm Reset

SCADA Manual

None.

SCADA Auto

For Grinders 1 and 2:

- The sludge grinder is interlocked with its associated pump in the **REMOTE** mode only. When REMOTE is selected at the Local Control Station, the sludge grinder will operate only when the pump is operating. In this mode the pump first starts and then, after a 2-second delay, the associated grinder starts.

For Sludge Grinders 3, 4, and 6.

- When a Sludge Grinder is available, it will start when there is a running feedback from its corresponding Sludge Recirculation Pump.
- Only during start-up, set time delay and ignore inrush current.
- De-rag Cycle: If the phase current reaches a PLC hardcoded set point at any time the PLC shall:
    - Stop the grinder, allowing time for it to coast to a stop.
    - Run grinder reverse direction at 60% speed.
    - Stop the grinder, allowing time for it to coast to a stop.
    - Restart grinder in the forward direction.
    - Upon restarting in the forward direction:
        - If amperage is still high the sequence is repeated.
        - If amperage is not high for more than 30 seconds, then the cleared-rag cycle is sequence is aborted.
- This de-rag cycle shall be repeated a total of four times (adjustable).
- If at any time the equipment runs for more than 30 seconds in the forward direction during the four attempts, the reversal counter shall be reset.
- Alarm Condition: If after four tries, however, the Jam condition still exists, the forward starter shall be de-energized, and after a 2-second delay, the reverse starter coil shall be energized for 1-sec then be de-energized.
- An Alarm Condition lockout circuit shall be established and remain in the alarm state (even if power is lost) until it is reset.
- The lockout circuit shall disable the automatic cycle, cause the Trip pilot light to be illuminated, the Trip Status contact to close, the Running pilot light to be extinguished, and the Run Status contact to open. Once the obstruction has been cleared, the Alarm Condition lockout circuit can be reset by moving the selector switch to the Off/Reset position.

SCADA Display
Status and Process Display
For Sludge Grinders 1 and 2: • Stopped / Running status. • Field / SCADA status. For Sludge Grinders 3, 4, and 6: • Sludge Grinder X Running Forward Status. • Sludge Grinder X Running Reverse Status. • Sludge Grinder X Remote Status. • Sludge Grinder X Auto Status. • Sludge Grinder X Manual Status. • Sludge Grinder X Speed Feedback. • Sludge Grinder X Amperage.
Operator Entries
Fore Sludge Grinders 1 and 2: None. For Sludge Grinders 3, 4, and 6: • Sludge Grinder X Auto/Manual Mode. • Sludge Grinder X Forward/Stop. • Sludge Grinder X Reverse/Stop. • Sludge Grinder X motor speed setpoint.
SCADA Alarms and Resets
For Sludge Grinders 1, 2, 3, 4, and 6: • Grinder FAIL. • Grinder FAULT. For Sludge Grinders 3, 4, and 6: • Grinder HIGH AMPERAGE. • Grinder FAULT.
Hard-Wired Interlocks
None.
Software Interlocks
For Sludge Grinders 3, 4, 6: • Remote/Auto Mode: Sludge Grinders only run when corresponding Sludge Recirculation Pump is running. • Remote/Auto Mode: Sludge Grinders shutdown on high amperage and become ‘unavailable’ after cycling through a “De-rag Cycle” sequence and still at high amperage. The corresponding Sludge Recirculation Pump then becomes unavailable and turns off.

Historical Trending and Run-time Counters
• Grinder run time hours.
Equipment Failure Sequence
For Sludge Grinders 1 and 2: • On a grinder FAIL alarm, the grinder will shut off and prevent operation of the pump unless it is placed in MANUAL. For Sludge Grinders 3, 4, and 6: • Remote/Auto Mode: Sludge Grinders shutdown on high amperage.
Equipment Automatic Failover Sequence
None.
Equipment (Auto/Manual) Restart After Power Interruption
None.

END OF SUPPLEMENT

Control Loop Description	DC2 Digester Sludge Recirculation Pumps (D60_120_CTL_020)

Process Description:

Digester Sludge Recirculation Pumps continuously pump digester contents from the digester through a heat exchanger and back into the digester. There are dedicated duty pumps for each digester and two swing pumps. One for Digesters 1 and 2 and one for Digester 3. Each pump has a check valve on its discharge. A flow meter is provided on the discharge of each spiral heat exchanger to detect loss or reduction of sludge flow rate.

Reference Drawing(s):	008-I-010A, 008-I-010B		
Last Update/Review:	03/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20P10201	Sludge Recirculation Pump 1	
20P10202	Sludge Recirculation Pump 2	
725P6703	Sludge Recirculation Pump 3	
725P6704	Sludge Recirculation Pump 4	Digester 3 swing pump
725P6706	Sludge Recirculation Pump 6	Digesters 1 and 2 swing pump

Instrumentation:

Tag No.	Description	Notes
725PIT6701	Sludge Recirculation Heat Exchanger 1 Sludge Discharge Flow Transmitter	0-650 gpm
725PIT6702	Sludge Recirculation Heat Exchanger 2 Sludge Discharge Flow Transmitter	0-650 gpm
725FIT6703	Sludge Recirculation Heat Exchanger 3 Sludge Discharge Flow Transmitter	0-650 gpm

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

None.

Motor Control Center

None.

MFR Control Center

None.

Local Control Station

Sludge Recirculation Pumps 1 and 2:

- Local Control Stations are provided with the following functions:
  - Selector switch with LOCAL/REMOTE selections.
  - Start button.

Sludge Recirculation Pumps 3, 4, and 6:

- Local Control Stations are provided with the following functions:
  - Selector switch with LOCAL, OFF/RESET, REMOTE selections.
  - Start button.
  - Stop button.

SCADA Control Operation and Alarm Reset

SCADA Manual

- With the LOCAL/REMOTE selector switch at the local control panel in REMOTE, control from SCADA is enabled.
- On SCADA, with the MANUAL/AUTO selector in MANUAL, either pump can be started and stopped from icons on the SCADA display.

SCADA Auto

- On SCADA, with the MANUAL/ AUTO selector in **AUTO**, the pump runs continuously unless its associated grinder has a FAULT.

SCADA Display

Status and Process Display

- Pump STOPPED/RUNNING status.
- FIELD / SCADA status.
- Sludge Recirculation Flow Rate.

Operator Entries

- None.

SCADA Alarms and Resets

- LOSS OF FLOW occurs when a pump is running or has stopped and flow is zero.
- Operator adjustable LOW FLOW alarm.
- PUMP FAIL occurs when a pump fails to start or fails to stop.

Hard-Wired Interlocks

None.

Software Interlocks

- Remote/Auto Mode: Sludge Recirculation Pump stops if corresponding Sludge Grinder fails.

Historical Trending and Run-time Counters

For Sludge Recirculation Pump 3, 4, and 6:

- Sludge Recirculation Sludge Pump run time hours.

For Sludge Recirculation Pump 1, 2, 3, 4, and 6:

- Sludge Recirculation Flow Rate.

Equipment Failure Sequence
None.
Equipment Automatic Failover Sequence
None.
Equipment (Auto/Manual) Restart After Power Interruption
None.

END OF SUPPLEMENT

Control Loop Description	DC2 Digesters Temperature Control (D60_120_CTL_060)

Process Description:

Digesters 1, 2, and 3 are 1,300,000-gallon anerobic digesters that are heated to 100 degrees F to support mesophilic digestion. Heat is provided with a spiral heat exchanger installed in a sludge recirculation loop. The sludge recirculation loop pump operates when the sludge inlet temperature to the heat exchanger drops to 100 degrees F. The inlet and outlet temperature and sludge flow rates are monitored. When the sludge temperature at the inlet of the heat exchanger is below setpoint, the sludge recirculation pump is started and a two-way flow control valve modulates heated water flow through the heat exchanger to achieve the temperature setpoint of the returning sludge until the sludge inlet temperature achieves setpoint.

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20M10301	Sludge Heat Exchanger 1	
20P10201	Sludge Recirculation Pump 1	
725FCV6618	Sludge Recirculation Heat Exchanger 1 Hot Water Control Valve	
20M10302	Sludge Heat Exchanger 2	
20P10202	Sludge Recirculation Pump 2	
725FCV6619	Sludge Recirculation Heat Exchanger 2 Hot Water Control Valve	
725HX6703	Sludge Heat Exchanger 3	
725P6703	Sludge Recirculation Pump 3	
725FCV6613	Sludge Recirculation Heat Exchanger 3 Hot Water Control Valve	
725P6704	Sludge Recirculation Pump 4	Digester 3 Swing Pump
725P6706	Sludge Recirculation Pump 6	Digesters 1 and 2 Swing Pump

Instrumentation:

Tag No.	Description	Notes
725PIT6701	Sludge Recirculation Heat Exchanger 1 Sludge Discharge Flow Transmitter	0-650 gpm
725TIT6611S	DC2 Sludge Recirculation Heat Exchanger 1 Hot Water Supply Temperature Transmitter	40-220 deg F
725TIT6611R	DC2 Sludge Recirculation Heat Exchanger 1 Hot Water Return Temperature Transmitter	40-220 deg F
725TIT6701A	DC2 Sludge Recirculation Heat Exchanger 1 Sludge Inlet Temperature Transmitter	40-220 deg F
725TIT6701B	DC2 Sludge Recirculation Heat Exchanger 1 Sludge Outlet Temperature Transmitter	40-220 deg F
725PIT6702	Sludge Recirculation Heat Exchanger 2 Sludge Discharge Flow Transmitter	0-650 gpm
725TIT6612S	DC2 Sludge Recirculation Heat Exchanger 2 Hot Water Supply Temperature Transmitter	40-220 deg F
725TIT6612R	DC2 Sludge Recirculation Heat Exchanger 2 Hot Water Return Temperature Transmitter	40-220 deg F
725TIT6702A	DC2 Sludge Recirculation Heat Exchanger 2 Sludge Inlet Temperature Transmitter	40-220 deg F
725TIT6702B	DC2 Sludge Recirculation Heat Exchanger 2 Sludge Outlet Temperature Transmitter	40-220 deg F
725FIT6703	Sludge Recirculation Heat Exchanger 2 Sludge Discharge Flow Transmitter	0-650 gpm
725TIT6613S	DC2 Sludge Recirculation Heat Exchanger 3 Hot Water Supply Temperature Transmitter	40-220 deg F
725TIT6613R	DC2 Sludge Recirculation Heat Exchanger 3 Hot Water Return Temperature Transmitter	40-220 deg F
725TIT6703A	DC2 Sludge Recirculation Heat Exchanger 3 Sludge Inlet Temperature Transmitter	40-220 deg F
725TIT6703B	DC2 Sludge Recirculation Heat Exchanger 3 Sludge Outlet Temperature Transmitter	40-220 deg F

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- None.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

- The local control panel at the pump has:
  - A LOCAL / REMOTE selector switch which when placed in **LOCAL**, enables control from Local Control Station. When placed in REMOTE, control is from SCADA.
  - In the LOCAL mode, the pump can be started or stopped locally, using START or STOP pushbuttons.

SCADA Control Operation and Alarm Reset

SCADA Manual

- START / STOP icons are on the SCADA screen which permit starting or stopping of the pumps when the Local Control Station selector is in **REMOTE**.
- The position for the two-way temperature control valve can be set in manual mode.

SCADA Auto

- When in **REMOTE** at Local Control Station and **AUTO** on the SCADA screen, the pump will:
  - Start pump when sludge temperature measured at the inlet of the heat exchanger falls to less than or equal to 99.9 degrees F for longer than 10 minutes.
  - Stop pump when sludge temperature measured at the inlet of the heat exchanger is greater than 100.1 degrees F, for longer than 10 minutes or the two-way control valve has been closed for 5 minutes.
- When the sludge inlet temperature is below sludge inlet temperature setpoint (user adjustable) the two-way control valve position closes via PID loop to increase the sludge return temperature setpoint (user adjustable).

SCADA Display

Status and Process Display

- Recirculation Pump Status.
- Sludge inlet temperature setpoint.
- Sludge inlet temperature.
- Sludge outlet temperature.
- Sludge recirculation flow rate.
- Two-way temperature control valve position.
- Hot water supply temperature.
- Hot water return temperature.

Operator Entries

- Sludge inlet temperature setpoint.
- Sludge outlet temperature setpoint.
- Heat Exchanger Recirculation Pump selection to AUTO or MANUAL.
- Heat Exchanger Recirculation Pump START / STOP when pump in MANUAL.

SCADA Alarms and Resets

- Digester temperature control valve failure:
  - Temperature control valve feedback position does not match commanded position for greater than 1 minute.
- Alarm when sludge temperature measured at the inlet of the heat exchanger is at or above 103 degrees F, and the Heat Loop Pump is not in AUTO.
- Alarm when sludge temperature measured at the inlet of the heat exchanger is at or below 98.0 degrees F (operator adjustable).
- HIGH HIGH TEMP when sludge temperature measured at the inlet of the heat exchanger is 103.0 degrees F.
- HIGH TEMP when sludge temperature measured at the inlet of the heat exchanger is 103.0 degrees F.
- LOW TEMP when sludge temperature measured at the inlet of the heat exchanger is 95.0 degrees F.
- HOT WATER HIGH TEMP measured at the inlet of the heat exchanger is 160 degrees F.
- Heat Exchanger Recirculation Pump START FAIL.
- Heat Exchanger Recirculation Pump STOP FAIL.
- Heat Exchanger Recirculation Pump LO TEMP NOT AUTO.
- Heat Exchanger Recirculation Pump FAULT.

Hard-Wired Interlocks

- None.

Software Interlocks

- None.

Historical Trending and Run-time Counters
• Sludge inlet temperature setpoint. • Sludge inlet temperature. • Sludge outlet temperature. • Sludge recirculation flow rate. • Two-way temperature control valve position. • Hot water supply temperature. • Hot water return temperature.
Equipment Failure Sequence
None.
Equipment Automatic Failover Sequence
None.
Equipment (Auto/Manual) Restart After Power Interruption
None.

END OF SUPPLEMENT

Control Loop Description

Heating Water Boilers

Process Description:

Heating Water Boilers 3 & 4 (725BLR6623 & 725BLR6624) work with the existing Heating Water Boilers 1 & 2 (20M22101 & 20M22102) and the engines in the cogeneration facility to provide heating water for the entire Site. Boiler pumps (20P20201, 20P20202, 725P6623, & 725P6624) are part of a decoupled loop that draws water from the primary heating loop, into the heating water boilers and back to the main heating water loop. Each boiler's associated pump will run continuously when the boiler is enabled.

At any time, operators can manually adjust the lead/lag arrangement for the four boilers which will dictate the order in which boilers are enabled to satisfy the heating load. Any boiler can also be placed into service mode, where both the boiler and associated circulation pump will ignore heating demand and remain offline. When digester gas is available, boilers 1 and 2 are enabled. If additional heat is required, boilers 3 and 4 are enable and a setpoint provided. If digester gas is not available, boilers 3 and 4 are enable and boilers 1 and 2 are disabled.

During normal operation, the boilers will always be available for heating unless in service mode, in fault, or powered off. The Primary Heating Water Loop Temp Setpoint (PHWLTS)(155 degrees F, adj.) will be used to stage boilers on and off and will drive the bypass valves and boiler leaving water temperature reset. When enabled due to heating demand, the lead boiler and its associated circulation pump will start, with the three-way bypass valve fully open to circulate water through the boiler. See the table provided below for a list of setpoints.

Boiler	Min Leaving Water Temp Setpoint (F, adj.)	Max Leaving Water Temp Setpoint (F, adj.)
20M22101	180	190
20M22102	180\	190
725BLR6623	155	180
725BLR6624	155	180

Condensing Natural Gas Boilers: The boiler will modulate flame until it achieves 90 percent of the Min Leaving Water Temp Setpoint sent by SCADA. At this point, the three-way valve will slowly move to a closed position (5 percent per second, adj.). After it is closed, the boiler's Leaving Water Temp Setpoint will be modulated between the Min and Max (3 degrees F per minute, adj) by SCADA to satisfy the PHWLTS. When heating demand falls and the Leaving Water Temp Setpoint reaches the Min value for 3 minutes (adj.), the boiler will be disabled, the bypass valve will fully open, and the circulation will run for another 2 minutes (adj) before shutting down.

Existing Dual Fuel Boilers: The boiler will modulate flame to maintain the Min Leaving Water Temp Setpoint sent by SCADA. As the first stage of heating, the three-way bypass valve will slowly modulate (5 percent per second, adj.) to satisfy the PHWLTS. If the three-way valve is fully closed for 1 minute (adj.), the boiler will enter the second stage of heating. For the second stage of heating, the bypass valve will remain closed and the Leaving Water Temp Setpoint will be modulated between the Min and Max (3 degrees F per minute, adj) by SCADA to satisfy the PHWLTS. A

Minimum Leaving Water Temp Setpoint of 180 degrees F has been chosen for the existing dual-fuel boilers to reduce the risk of corrosion when burning digester gas. When heating demand falls and Leaving Water Temp Setpoint reaches Min value for 1 minute (adj.), boiler will return to first stage of heating where Min Leaving Water Temp Setpoint is maintained and three-way bypass valve modulates to maintain PHWLTS. When three-way bypass valve is fully open for 1 minute, the boiler will be disabled and the circulation will run for another 2 minutes (adj) before shutting down.

After a boiler runs for 2[MI1] minutes (adj.) at the Max Leaving Water Temp Setpoint, the next boiler in the lead/lag arrangement will be commanded to run. When multiple boilers are enabled, only the most recently enabled boiler will modulate, while the other active boilers run in a steady-state condition. Additional boilers will control as described above, and if the PHWLTS is not satisfied, another will be brought online until all boilers are enabled.

The Emergency Power Off (EPO) button provides emergency shutdown for all boilers. When pressed, each boiler shall enter emergency shutdown mode where fuel feed is disabled but draft fans and circulations pumps run for an additional 60 seconds (adj.) before complete shutdown. The EPO shall not interrupt power to the boilers unless recommended by the manufacturer.

Reference Drawing(s):	008-I-011, 008-I-011A		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20M22101	Heating Water Boiler 1	
	Heating Water Boiler 1 Temperature Control Valve	
20M22102	Heating Water Boiler 2	
	Heating Water Boiler 2 Temperature Control Valve	
725BLR6623	Heating Water Boiler 3	
	Heating Water Boiler 3 Temperature Control Valve	
725BLR6624	Heating Water Boiler 4	
	Heating Water Boiler 4 Temperature Control Valve	
20P20201	Boiler 1 Loop Pump	
20P20202	Boiler 2 Loop Pump	
725P6623	Boiler 3 Loop Pump	
725P6624	Boiler 4 Loop Pump	

Instrumentation:

Tag No.	Description	Notes
716TIT6601	Cogen Input Hot Water Temperature	0-240 deg F
716TIT6602	Cogen Output Hot Water Temperature	0-240 deg F
750FIT6601	Primary Heat Loop Hot Water Flow	0-2,000 gpm
750TIT6601	Primary Heat Loop Supply Temperature	

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- None.

Motor Control Center

- None.

MFR Control Center

- Heating Water Boilers 3 and 4 are self-contained unit and will each have a manufacturers control panel mount on face of equipment. All aspects of operation can be monitored and adjusted at individual control panels. The boiler control panels will be linked via a local network as per manufacturer's instructions. One of the boilers will act as the master panel and the other will act as slave panel. The master panel will have a network connection to SCADA. SCADA will enable/disable the boiler plant, provide a heating water supply temperature setpoint, monitor for faults. Boiler firing and rate of fire will be controlled by the master boiler control panel to achieve temperature setpoint. Boiler control panel to operate individual boiler isolation valves based upon boiler sequencing and rate of fire.

Local Control Station

- None.

SCADA Control Operation and Alarm Reset

SCADA Manual

- Heating water supply temperature setpoint for high efficiency boiler plant can be manually overridden.

SCADA Auto

- When Digester Gas is available:
  - When enabled locally, Boilers 1 and 2 operate to meet setpoints on local controllers.
- SCADA to enable Boilers 3 and 4 when heating water supply temperature is less than calculated heating water supply temperature for greater than 60[MI2] minutes.
- When Digester Gas is NOT available:
  - SCADA to enable Boilers 3 and 4 and operate to meet setpoint.
  - Lag boiler will start if the temperature setpoint is not met after XX minutes.

SCADA Display

Status and Process Display

- Boiler READY.
- Boiler FAULT.
- Boiler RUNNING.
- Flame FAIL.
- Temperature Control Valve Position.
- Primary Heat Loop Water Flow.
- Primary Heat Loop Supply Temperature.
- Heating Water Supply Temperature Setpoint.

Operator Entries

- Boiler Service Mode.
- Boiler Lead/Lag Selection.
- Heating Water supply temperature.

SCADA Alarms and Resets

- Boiler Flame FAIL.
- Boiler FAIL.
- Boiler Loop Pump FAIL.

Hard-Wired Interlocks

- If the emergency E-stop is pressed, the boilers will be in shutdown mode where fuel feed is disabled but draft fans and circulations pumps run for an additional 60 seconds.

Software Interlocks

- If dedicated hot water pump fails, associated boiler will shut down.

Historical Trending and Run-time Counters

- Loop pump run hours.
- Natural gas flow.
- Boiler run hours.

Equipment Failure Sequence

- None.

Equipment Automatic Failover Sequence
• None.
Equipment (Auto/Manual) Restart After Power Interruption
• All equipment to automatically restart.

END OF SUPPLEMENT

Control Loop Description	Hot Water Pumps and Heat Loop

Process Description:

Hot Water Pumps:
Primary Heat Loop Circulation Pumps (725P6601 & 725P6602), installed in the control room at Digester Complex No. 2 (DC2), provide heating water flow for all facilities and secondary heating water loops onsite. Heat is provided by engines at the Cogen facility and the new and existing boilers at DC2.

These pumps operate in a Lead/Standby arrangement. As two-way valves in the heating water system open and close during normal operation, pump speed modulates to maintain a differential pressure setpoint measured in the pumps' supply and return headers. This setpoint will be established by the Testing, Adjusting, and Balancing contractor during startup so adequate flow is available at the most remote heating loads.

At the interchange between the primary and secondary heating loops at the Brown Grease Receiving Facility (BGRF), control valve (715FCV6611) is used to control flow of heating water from the primary heating loop into the secondary heating loop. This valve will modulate 100 percent open when the Secondary Heating Loop Temperature (TIT6602) falls below setpoint (150 degrees F, adj.).

To maintain minimum flow through the Primary Heat Loop Circulation Pumps during low heating conditions, an autoflow bypass valve (725BV6611) has been installed at the interchange between the primary and secondary heating loops at the Brown Grease Receiving Facility. This will allow a small amount of flow to circulate from the HWS to the HWR in the primary heating loop.

At each heating load, two-way valves are installed that modulate open when there is a call for heat. Heating coils or heat exchangers equipped with a coil pump will have the pump enabled when the valve is more than 0 percent open.

Primary Heat Loop Calculation:
The Primary Circulation Loop is provided with instrumentation to allow calculation of heat generated by the Cogen Engines and the boilers. HWS flow and temperature are measured at DC2 downstream of the boilers and pumps. HWR temperatures are measured pre-Cogen and post-Cogen.

Heat load used in Digester Complex 2 can be calculated as the total heat generated minus the heat used in the Brown Grease Building and the East Plant. See Secondary Heat Loop control description also.

Refer to separate control loop for calculation of heat generated.

Secondary Heat Loop Pumps:
Refer to separate control loop for control of the secondary loop pumps located at the BGRF.

Reference Drawing(s):	008-I-011, 008-I-012		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
725P6601	Primary Heat Loop Pump 1	(Old Tag: 20P0101)
725P6602	Primary Heat Loop Pump 2	(Old Tag: 20P0102)

Instrumentation:

Tag No.	Description	Notes
716TIT6601	Cogen Input Hot Water Temperature	0-240 deg F
716TIT6602	Cogen Output Hot Water Temperature	0-240 deg F
750FIT6601	Primary Heat Loop Hot Water Flow	0-1,600 gpm
750TIT6601	Primary Heat Loop Supply Temperature	
725PIT6601A	Primary Heat Loop Return Pressure	
725PIT6601B	Primary Heat Loop Supply Pressure	

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- At the VFD, a display panel is provided to monitor the operating parameters. A keypad is provided to allow manual adjustment of START, STOP, and SPEED control functions from the VFD when LOCAL is selected at the pump's Local Control Station. The following signals are monitored or controlled by SCADA:
  - Remote Status.
  - Running Status.
  - Fault summary alarm.
  - Speed output of VFD (%).
  - Run control to VFD.
  - Speed control to VFD Third Level.
- The fault summary alarm deactivates the controls at the VFD and stops the pump. This alarm can be reset only at the VFD.
- In addition, displays for:
  - VFD Running.
  - VFD Failure.
  - VFD in PANEL (i.e., Keypad) or REMOTE (i.e., PLC or Local Control Station in LOCAL) mode.
  - Fault Reset pushbuttons have been provided on the VFD panel.

Motor Control Center
• None.
MFR Control Center
• None.
Local Control Station
• None.
SCADA Control Operation and Alarm Reset
SCADA Manual
• Place the Pump LOCAL-REMOTE selector in REMOTE. • Place the MANUAL-AUTO selector at the HMI graphics in MANUAL. • Press the HMI START button to start the Pump. • Press the HMI STOP button to stop the Pump.
SCADA Auto
• Pumps run as Duty/Standby. • Always run the Duty pump. If the Duty pump fails, run the Standby pump in its place. • Pump speed is adjusted to maintain a differential pressure setpoint between the HWS and HWR lines.
SCADA Display
Status and Process Display
• Differential Pressure. • HWS Flow Rate. • HWS Temperature. • Calculated Heat usage. • Pump Running. • Pump Speed.
Operator Entries

• For each Pump:
  o SCADA MANUAL/AUTO selection.
  o MANUAL START/STOP control.
• Differential Pressure setpoint.
• DUTY/STANDBY selection.

SCADA Alarms and Resets
• LOW HWS Temperature. • Pump FAIL.
Hard-Wired Interlocks
• None.
Software Interlocks
• None.

Historical Trending and Run-time Counters
• Pump Hours. • Pump Speed. • Primary Heat Loop Hot Water Flow. • Primary Heat Loop Supply Temperature. • Primary Loop Pump Differential Pressure.
Equipment Failure Sequence
• None.
Equipment Automatic Failover Sequence
• If duty pump fails, start the standby pump.
Equipment (Auto/Manual) Restart After Power Interruption
• None.

END OF SUPPLEMENT

Control Loop Description	Secondary Heat Loop

Process Description:

Secondary Heat Loop Circulation Pumps provide hot water circulation to heat loads for FOG Waste Receiving, Brown Grease Building HVAC, and to the East Plant heat loads. Secondary Heat Loop Pumps are operated as DUTY/STANDBY. They are adjustable speed pumps that are controlled to maintain a set differential pressure between the Secondary Loop Supply and Return lines.

The Secondary Circulation Loop is provided with instrumentation to allow calculation of heating loads in the Brown Grease Building and the East Plant.

Last Update: 08/2025	**Approved By:**

Equipment

Unit Equipment:

Equipment Name	Tag Number	Type	Rating
Secondary Heat Loop Circulation Pump 1	715P6601		
Secondary Heat Loop Circulation Pump 2	715P6602		

Instrumentation

Instrument Name	Tag Number	Type	Range
Secondary Heat Loop HWS Suction Pressure Gauge	715PI6601		0 - 100 psig
Secondary Heat Loop HWS Pressure Transmitter	715PIT6601		0 - 100 psig
Secondary Heat Loop HWS Pressure Differential Transmitter	715PDIT6601		0 - 40 psig
Secondary Heat Loop HWS Temperature Transmitter	715TIT6601		0 - 240 deg F
Secondary Heat Loop HWS Flow Transmitter	715FIT6601	Magmeter	0 – 1,200 gpm
Secondary Heat Loop HWR Temperature Transmitter	715TIT6602		0 - 240 deg F
East Plant Heat Loop HWR Temperature Gauge	715TI6603		32 - 240 psig

Control Strategies
A. Local Control Operation and Alarm Reset:
1. **Manufacturer-Supplied Control Panels:** N/A
2. **Motor Control Center/VFD:** Motor overload RESET.
3. **MFR Control Center:** None.
4. **Local Control Station:** None.
5. **Intermediate Control Panel:** N/A.
B. SCADA Control Operation and Alarm Reset:
1. **SCADA Manual:** a. Place the Pump LOCAL-REMOTE selector in REMOTE. b. Place the MANUAL-AUTO selector at the HMI graphics in MANUAL. c. Press the HMI START button to start the Pump. d. Press the HMI STOP button to stop the Pump.
2. **SCADA Auto:** a. Pumps run as Duty/Standby. b. Always run the Duty pump. If the Duty pump fails, run the Standby pump in its place. c. Pump speed is adjusted to maintain a differential pressure setpoint between the HWS and HWR lines.
SCADA Display
A. Status and Process Display: 1. For each Pump: a. ON status. b. REMOTE mode. c. Pump Speed. 2. Differential Pressure. 3. HWS Pressure. 4. HWS Flow Rate and Total. 5. HWS Temperature. 6. HWR Temperature. 7. Calculated Heat Used, in BTU/hr: $H = 500 * Q * (T_{HWS} - T_{HWR})$, where Q is in gpm and T is in degrees F.
B. Operator Entries: 1. For each Pump: a. SCADA MANUAL/AUTO selection. b. MANUAL START/STOP control. 2. Differential Pressure setpoint. 3. DUTY/STANDBY selection.

C. SCADA Historical Trending: 1. Differential Pressure. 2. HWS Pressure. 3. HWS Flow rate and total. 4. HWS Temperature. 5. HWR Temperature. 6. Calculated Heat usage. 7. For each Pump: Speed.
SCADA Alarms and Interlocks
A. Alarms: 1. LOW HWS Temperature. 2. LOW HWR Temperature. 3. HIGH Differential Pressure. 4. For each Pump: a. FAIL alarm.
B. Hard-Wired Interlocks: None.
C. Software Interlocks: None.
Programming Requirements
A. Equipment Run Time Counters: Run Time for each Pump.
B. Equipment Failure Sequence: None.
C. Equipment Automatic Failover Sequence: If Duty pump fails, start the Standby pump.

END OF SUPPLEMENT

Control Loop Description	Digesters 1, 2, and 3 Mixers (D60_120_CTL_030)

Process Description:

Digester Complex 2 consists of three 1,300,000-gallon, reinforced concrete, mesophilic anaerobic digesters designed for digestion utilizing heating and mixing of the digester sludge. The digesters receive feed sludge pumped from the digester feed tanks located in the Solids Building. A single mixer with dual impellers is mounted on each fixed digester cover and provides complete mixing of the sludge within the digester. The sludge is recirculated and heated continuously through a spiral heat exchanger to maintain 100 degrees F.

Each digester receives feed sludge pumped from the digester feed tanks with the raw sludge introduced into the sludge recirculation return line to each digester. Each digester also receives FOG waste from the Brown Grease Receiving Facility (BGRF), with the FOG waste introduced into the sludge recirculation line. Dedicated FOG feed waste pumps pump stored FOG waste from the BGRF.

Digested sludge from each digester overflows to a common digester sludge sump. Digested sludge is pumped to Digester Complex 1 holding tanks for dewatering.

Reference Drawing(s):	008-I-016		
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20T10401	Digester 1	
20M10401	Digester 1 Mixer	Constant speed
20P10401	Digester 1 Mixer Oil Pump	Constant speed
20T10402	Digester 2	
20M10402	Digester 2 Mixer	Constant speed
20P10402	Digester 2 Mixer Oil Pump	Constant speed
725T6503	Digester 3	
725MX6503	Digester 3 Mixer	Constant speed
725P9201	Digester 3 Mixer Oil Pump	Constant speed
NA	Overflow Sump	

Instrumentation:

Tag No.	Description	Notes
750LIT6501	Digester 1 Radar Level Transmitter	
20LSL10401	Digester 1 Mixer Oil Level Switch	
20FSL10401	Digester 1 Mixer Lube Pump Flow Switch	
725CIT6501	Digester 1 Mixer Amperage	0-100 A
750LIT6502	Digester 2 Radar Level Indicating Transmitter	
20LSL10402	Digester 2 Mixer Oil Level Switch	
20FSL10402	Digester 2 Mixer Lube Pump Flow Switch	
725CIT6501	Digester 1 Mixer Amperage	0 - 100 A
20LIT10601	Overflow Sump Level Indicating Transmitter	
725FSL6503	Digester 3 Mixer Lube Pump Flow Switch	
725LIT6503	Digester 3 Level Radar Transmitter	0 - 50 ft
725PIT6903	Digester 3 Digester Gas Pressure Transmitter	0 - 25 in WC
725FIT6903	Digester 3 Digester Gas Flow Transmitter	0 - 500 scfm
725LIT6904	Digester 3 Sludge Level Differential Transmitter	25 in WC
725CIT6503	Digester 3 Mixer Amperage	0 - 100 A

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- None.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

- Digester Mixers:
  - The Local Control Stations for the Digester Mixers have a REVERSE/OFF/FORWARD selector switch for the mixer motor.
  - There is also an AUTO/ON selector switch for each of the mixers' lube oil pumps.
    - In AUTO, when mixer is called to run, lube oil pump starts first. When lube oil flow switch proves oil flow, mixer motor will start. If mixer motor is turned off, lube oil pump will stop.
    - In ON, the lube oil pump runs continuously.

SCADA Control Operation and Alarm Reset

SCADA Manual

- None.

SCADA Auto

- None.

SCADA Display

Status and Process Display

- For each Digester:
  - Digester Level.
  - Digester HIGH Level alarm.
  - Digester LOW Level alarm.
  - Mixer running FORWARD or REVERSE.
  - Lube pump RUNNING.
  - Overflow Sump Level.

Operator Entries

- None.

SCADA Alarms and Resets

- Digester Mixer Fault.
- Digester Mixer Oil Flow Low.
- Digester Mixer Lube Fault.
- Digester Mixer Amperage.

Digester Level Alarms and Setpoints:

High-high	34 feet
Overflow	33.95 feet
High	30 feet
Low	13.7 feet
Low-low	9.8 feet

Overflow Sump Level Alarms and Setpoints:

High-high	16 feet
Low-low	4 feet

Mixer Amperage Alarms:

Low	60 A
High	100 A

Hard-Wired Interlocks

- None.

Software Interlocks

- None.

Historical Trending and Run-time Counters

- Digested Sludge Sump Level.
- Digester 1 Level.
- Digester Mixer 1 Amperage.
- Digester 2 Level.
- Digester Mixer 1 Amperage.
- Digester 3 Level.
- Digester 3 Differential Pressure.
- Digester Mixer 3 Amperage.

Equipment Failure Sequence

None.

Equipment Automatic Failover Sequence

None.

Equipment (Auto/Manual) Restart After Power Interruption

None.

END OF SUPPLEMENT

Control Loop Description	Digester Feed Pumping (D60_150_CTL_020)

Process Description:

Thickened primary sludge, gravity thickener scum, and centrifuge thickened waste activated sludge are combined in two digester feed tanks (DFT) and can be fed to Digesters 1, 2, and 3 in Digester Complex 2 (DC2) or Digesters 2 (DSHT 3) and 3 (DSHT 2) at Digester Complex 1 (DC1) using three variable speed progressive cavity pumps. Typically, the digesters at DC2 are in service with the digesters at DC1 providing redundant digestion capacity to one digester at DC2.

The feed valves at the DC2 digesters are normally ONLINE and in AUTO with the flow alternating between them at operator adjustable feed cycle times.

DFT 1 can also be used for High Strength Food Waste, which is delivered by truck and is also pumped to the DC2 digesters.

Digester feed is measured by a flow meter on the feed pipe to DC2 or DC1. Primary scum is measured by a flow meter and added to the feed piping prior the flow meter of the Digester Feed.

Digester Feed Pumping to DC2 and DC1:
If digesters are online at both DC 2 and DC 1, Digester Feed Pump 2 (west pump) will be dedicated to feed DC2 digesters and Digester Feed Pump 1 (east pump) will be dedicated to feed DC1 digesters. Digester feed pump 3 (middle pump) will be the swing pump. In case of failure of Digester Feed Pumps 1 or 2, valves in the discharge header can be cycled to direct feed using the swing pump to the selected discharge destination.

Feed Pump Suction Options:
Any of the three pumps can draw from either digester feed tank.

DFT 1 (west tank) has an option for an alternative suction path should the suction line have problems with plugging. The normal option would be to draw from the lower suction line which draws from the digester feed tank sump. If this line becomes plugged, operators can choose to use the top “straight in” suction line by manually adjusting valves. This line can draw down the tank completely. DFT 2 (east tank) draws from the sump only and has no alternative path.

Sludge Only Mode:
If no High Strength feed is being used, either DFT can be selected as active tank for sludge feeding. Speed of pump(s) that are in auto will be controlled to maintain a level of 8 feet in the active tank.

High Strength Mode:
If High Strength Feed is being used, DFT 2 will be used for sludge feeding and Feed Pump 1 will be used to maintain the sludge level at 8 feet. DFT 1 will hold the High Strength Feed and Digester Feed Pump 2 will operate at its minimum speed (20%) for an operator adjustable percentage of each digester feeding cycle.

Pump 3 can be selected to operate as either Pump 1 or Pump 2.

NOTE: See separate control loop descriptions for Digester Feed Grinders, Digester Feed Tanks and Mixers, and Digester Complex 2 Digester Feed Valves, Digester Complex 1 Digester Feed Valves.

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
11P31101	Digester Feed Pump 1	50-300 gpm (20-100%)
11P31102	Digester Feed Pump 2	50-300 gpm (20-100%)
11P31102	Digester Feed Pump 2	50-300 gpm (20-100%)
710FV3811	Digester Feed Pump Discharge Manifold Control Valve DC 1	
710FV3812	Digester Feed Pump Discharge Manifold Control Valve Swing	
710FV3813	Digester Feed Pump Discharge Manifold Control Valve DC 2	

Instrumentation:

Tag No.	Description	Notes
11LE31201	Digester Feed Tank 1 Level Element	0 - 12 ft
11LIT31201	Digester Feed Tank 1 Level Indicating Transmitter	
11LE31202	Digester Feed Tank 2 Level Element	0 - 12 ft
11LIT31202	Digester Feed Tank 2 Level Indicating Transmitter	
11FE/FIT31101	Digester Feed Flow Meter to Digester Complex 2	0 - 750 gpm
11PIT31101	Digester Feed Pump 1 Discharge Pressure	0 - 200 psi
11PIT31102	Digester Feed Pump 2 Discharge Pressure	0 - 200 psi
11PIT31103	Digester Feed Pump 3 Discharge Pressure	0 - 200 psi

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- At VFD, a display panel is provided to monitor the operating parameters. A keypad is provided to allow manual adjustment of START, STOP, and SPEED control functions from the VFD when LOCAL is selected at the pump's Local Control Station. The following signals are monitored or controlled by SCADA:
  - Remote Status.
  - Running Status.
  - Fault summary alarm.
  - Speed output of VFD (%).
  - Run control to VFD.
  - Speed control to VFD Third Level.
- The fault summary alarm deactivates the controls at the VFD and stops the pump. This alarm can be reset only at the VFD.
- In addition, displays for:
  - VFD Running.
  - VFD Failure.
  - VFD in PANEL (i.e., Keypad) or REMOTE (i.e., PLC or Local Control Station in LOCAL) mode.
  - Fault Reset pushbuttons have been provided on the VFD panel.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

Digester Feed Pumps:

- Each digester feed pump has a Local Control Station that consists of:
  - A LOCAL-REMOTE selector switch.
  - START and STOP pushbuttons.
  - Pump 1-OFF-Pump 2 selector switch (Digester Feed Pump 3 only).
- Switching the LOCAL-REMOTE selector switch to LOCAL will allow the START and STOP push buttons to start and stop the pump. Local speed control is set from the VFD.
- Switching the LOCAL-REMOTE selector switch to REMOTE allows control from either the VFD panel or the PLC.

  The PUMP 1-PUMP 2-OFF selector switch allows Digester Feed Pump 3 to be used in the place of either Pump 1 or 2.

Digester Feed Pump Discharge Manifold Control Valves:

- All local control is provided at each valve actuator.
- Operators select the operating mode via LOCAL-REMOTE (LR) selector at the valve actuator. Operation in each mode is described below:
    - LOCAL MODE:
        1. Place the LR selector in LOCAL position.
        2. The valve opens when the OPEN button is pressed.
        3. The valve closes when the CLOSE button is pressed.
    - REMOTE MODE:
        1. Place the LR selector in REMOTE position.
        2. The valve opens when a remote OPEN command is received from the SCADA system.
        3. The valve closes when a remote CLOSE command is received from the SCADA system.

SCADA Control Operation and Alarm Reset

SCADA Manual

Digester Feed Pumps:

- With the LOCAL/REMOTE selector at the Local Control Station in REMOTE, control from SCADA is enabled.
    - From SCADA, either MANUAL or AUTO control is selected.
    - In MANUAL, pumps can be started or stopped from SCADA icons.

Speed Control as % of maximum can also be set from SCADA while in MANUAL.

Digester Feed Pump Discharge Manifold Control Valves:

- Place the Valve LOCAL-REMOTE selector in REMOTE.
- Place the MANUAL-AUTO selector at the HMI graphics in MANUAL.
- Press the SCADA OPEN button to open the valve.
- Press the SCADA CLOSE button to close the valve.

SCADA Auto

Digester Feed Pumps:

- The LOCAL/REMOTE selector at the Local Control Station for digester feed pumps must be in the REMOTE position for SCADA control. From the SCADA Digester Feed Screen:
    - Select AUTO for each digester feed pump.
    - Turn the High Strength Feed Mode ON or OFF, if the High Strength Mode is OFF, SLUDGE ONLY Mode is ON).
    - If the High Strength Feed Mode is OFF a selector switch must be set to either Digester Feed Tank 1 or Digester Feed Tank 2 in order to choose the level transmitter that will be used to control the pump speed to maintain an 8-foot level in the active tank.

Digester Feed Pump Discharge Manifold Control Valves:

- In SCADA AUTO mode, the digester feed pump discharge manifold valves automatically open and close based on the Destination Complex and whenever Digester Feed Pump 1 or Pump 2 fails and Digester Feed Pump 3 is placed into service.
- Only DC2 In Service:
    - Digester Feed Pump Discharge Manifold Control Valve DC 1 - CLOSED.
    - Digester Feed Pump Discharge Manifold Control Valve Swing - OPEN.
    - Digester Feed Pump Discharge Manifold Control Valve DC 2 - OPEN.
- DC2 and DC1 In Service:
    - Digester Feed Pump Discharge Manifold Control Valve DC 1 - OPEN.
    - Digester Feed Pump Discharge Manifold Control Valve Swing - CLOSED.
    - Digester Feed Pump Discharge Manifold Control Valve DC 2 - OPEN.

Sludge Only Mode:

Any pump that is in auto will adjust its speed to maintain an 8 ft level in the active sludge tank. Normally only one pump will be in SCADA Auto. The pump speed will vary from 20% to 100% (~50-300 gpm). If the active tank falls below 3 feet a low-level interlock will stop the feed pump until the level of the active tank rises above 8 feet.

In Sludge only mode, feed to each digester will proceed sequentially in order of:
DC 1 DSHT 2 -> DC 1 DSHT 3 -> DC2 Dig 1 -> DC2 Dig 2 -> DC2 Dig 3. Each destination will have operator adjustable timer to adjust pump time. After time has expired, the next destination in sequence will begin.

Each complex will have operator selectable pump (Pump 1, 2, or 3) which will begin feeding when the sequence is calling for that complex.

When advancing in the sequence between complex's, the next digester feed valve will open and the current digester feed pump will stop. After the next digester feed valve is open, the current digester feed valve can close. Once the next digester feed valve is open, the next digester feed pump will start.

When advancing in the sequence within the same complex, the next digester feed valve will open, once open the current digester feed valve will close. Digester feed pumping does not stop.

High Strength Feed Mode *Currently Disabled*

DFT 2 will be the active sludge tank. Digester Feed Pump 1 will normally be used to feed sludge to the digesters as described for Sludge Only Mode.

DFT 1 will store the High Strength food waste. This waste will normally be fed to the digesters at an average rate of ~3.5 gpm. Feed Pump 2 will normally be used for the High Strength. It will operate at is minimum speed of 20%, delivering ~50 gpm when it is running. It will turn on for an operator

adjustable percentage (0-50%) of the feed cycle to each digester (e.g. if a digester has a 20 minute feed cycle time and the High Strength Feed Mode CYCLE % is set to 5.0%, the High Strength Feed Pump will run for 1 minute at the start of each Digester feeding cycle). If both digester feed valves are not online and in auto, the High Strength Feed Pump will operate on its own 20-minute cycle, turning on for a percentage of this time.

Digester Feed Pump 3 can operate as either Digester Feed Pump 1 or Digester Feed Pump 2. In High Strength Feed Mode, it if is selected to run as Feed Pump 1, it will only run if Feed Pump 1 is not running and therefore will serve as a backup pump.

SCADA Display

Status and Process Display

- HIGH STRENGTH/SLUDGE ONLY Modes.
- All Pumps: FIELD/SCADA.
- All Pumps: AUTO/MANUAL.
- All Pumps: Destination Complex.
- Each Digester (DC1 and DC2) Feed Time.
- Pump 3 Only: PUMP 1/PUMP 2/OFF.
- RUNNING status.
- FAULT summary alarm.
- % speed output of VFD.
- Digester Feed Tank 1 and 2 Level.
- Primary scum feed rate indication (0–300 gpm).
- Combined thickened sludge and primary scum fed rate indication to Digester Complex.
- For each digester feed pump discharge manifold valve:
    - Fully OPEN status.
    - Fully CLOSED status.
    - Valve in REMOTE mode.

Operator Entries

- HIGH STRENGTH MODE ON/OFF.
- All Pumps AUTO/MANUAL.
- All Pumps MANUAL SPEED SETPOINT (%).
- All Pumps: Destination Complex.
- Each Digester (DC1 and DC2) Sequence Feed Time.
- High Strength Mode FEED CYCLE %.
- SCADA MANUAL/AUTO selection for each digester feed pump discharge manifold valve.
- SCADA MANUAL OPEN and CLOSE buttons for each digester feed pump discharge manifold valve.

SCADA Alarms and Resets

- Digester Feed Flow Broken Transmitter (Brkn Xmtr).
- Digester Feed Pump Start FAIL.
- Digester Feed Pump Stop FAIL.
- Digester Feed Pump Pressure HI (90 psi).
- Digester Feed Pump FAULT.
- Digester Overflow Sump HIGH-HIGH.

Hard-Wired Interlocks

- HIGH discharge pressure stops a pump (hardwired to VFD) and is currently set at 90 psi.

Software Interlocks

- LOW-LOW level.
- In Sludge Only Mode, pumps will stop if the level in the active tank is below 3.0 feet and will automatically restart when the tank level rises to 8.0 feet.
- In any SCADA control mode pumps will stop if the level in their associated feed tank falls below 3.0 feet. This interlock prevents pumps from running dry and will be released when the level rises above 3.2 feet.
- Grinder Fail.
- Start Fail.
- Stop Fail.
- VFD Fail.
- If digester feed pump 3 is selected one of the digester feed pump discharge manifold valves must be open.
    - Destination Complex:
        - DC1: 710FV3812 must be OPEN.
        - DC2: 710FV3813 must be OPEN.

Historical Trending and Run-time Counters

- Feed rate and feed volume in gallons to each operating digester and to all digesters.
- Primary scum volume in gallons.
- Raw sludge flow to digesters.
- Digester Feed Tank 1 and 2 Levels.
- Digester Feed Pumps Speed.

Equipment Failure Sequence

- Digester Feed Pump 3 can be selected to run in place of Pump 1 or Pump 2.

Equipment Automatic Failover Sequence

- In High Strength Feed Mode if Digester Feed Pump 3 is selected for Pump 2, it will automatically run only if Pump 2 is not running when the High Strength Feed pump is called to run.

Equipment (Auto/Manual) Restart After Power Interruption

None.

END OF SUPPLEMENT

Control Loop Description	Digester Feed Pumping (D60_150_CTL_020)

Process Description:

Thickened primary sludge, gravity thickener scum, and centrifuge thickened waste activated sludge are combined in two digester feed tanks (DFT) and can be fed to Digesters 1, 2, and 3 in Digester Complex 2 (DC2) or Digesters 2 (DSHT 3) and 3 (DSHT 2) at Digester Complex 1 (DC1) using three variable speed progressive cavity pumps. Typically, the digesters at DC2 are in service with the digesters at DC1 providing redundant digestion capacity to one digester at DC2.

The feed valves at the DC2 digesters are normally ONLINE and in AUTO with the flow alternating between them at operator adjustable feed cycle times.

DFT 1 can also be used for High Strength Food Waste, which is delivered by truck and is also pumped to the DC2 digesters.

Digester feed is measured by a flow meter on the feed pipe to DC2 or DC1. Primary scum is measured by a flow meter and added to the feed piping prior the flow meter of the Digester Feed.

Digester Feed Pumping to DC2 and DC1:
If digesters are online at both DC 2 and DC 1, Digester Feed Pump 2 (west pump) will be dedicated to feed DC2 digesters and Digester Feed Pump 1 (east pump) will be dedicated to feed DC1 digesters. Digester Feed Pump 3 (middle pump) will be the swing pump. In case of failure of Digester Feed Pumps 1 or 2, valves in the discharge header can be cycled to direct feed using the swing pump to the selected discharge destination.

Feed Pump Suction Options:
Any of the three pumps can draw from either digester feed tank.

DFT 1 (west tank) has an option for an alternative suction path should the suction line have problems with plugging. The normal option would be to draw from the lower suction line which draws from the digester feed tank sump. If this line becomes plugged, operators can choose to use the top “straight in” suction line by manually adjusting valves. This line can draw down the tank completely. DFT 2 (east tank) draws from the sump only and has no alternative path.

Sludge Only Mode:
If no High Strength feed is being used, either DFT can be selected as active tank for sludge feeding. Speed of pump(s) that are in auto will be controlled to maintain a level of 8 feet in the active tank.

High Strength Mode:
If High Strength Feed is being used, DFT 2 will be used for sludge feeding and Feed Pump 1 will be used to maintain the sludge level at 8 feet. DFT 1 will hold the High Strength Feed and Digester Feed Pump 2 will operate at its minimum speed (20%) for an operator adjustable percentage of each digester feeding cycle.

Pump 3 can be selected to operate as either Pump 1 or Pump 2.

NOTE: See separate control loop descriptions for Digester Feed Grinders, Digester Feed Tanks and Mixers, and Digester Complex 2 Digester Feed Valves, Digester Complex 1 Digester Feed Valves.

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
11P31101	Digester Feed Pump 1	50-300 gpm (20-100%)
11P31102	Digester Feed Pump 2	50-300 gpm (20-100%)
11P31102	Digester Feed Pump 2	50-300 gpm (20-100%)
710FV3811	Digester Feed Pump Discharge Manifold Control Valve DC 1	
710FV3812	Digester Feed Pump Discharge Manifold Control Valve Swing	
710FV3813	Digester Feed Pump Discharge Manifold Control Valve DC 2	

Instrumentation:

Tag No.	Description	Notes
11LE31201	Digester Feed Tank 1 Level Element	0 - 12 ft
11LIT31201	Digester Feed Tank 1 Level Indicating Transmitter	
11LE31202	Digester Feed Tank 2 Level Element	0 - 12 ft
11LIT31202	Digester Feed Tank 2 Level Indicating Transmitter	
11FE/FIT31101	Digester Feed Flow Meter to Digester Complex 2	0 - 750 gpm
11PIT31101	Digester Feed Pump 1 Discharge Pressure	0 - 200 psi
11PIT31102	Digester Feed Pump 2 Discharge Pressure	0 - 200 psi
11PIT31103	Digester Feed Pump 3 Discharge Pressure	0 - 200 psi

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- At VFD, a display panel is provided to monitor the operating parameters. A keypad is provided to allow manual adjustment of START, STOP, and SPEED control functions from the VFD when LOCAL is selected at the pump's Local Control Station. The following signals are monitored or controlled by SCADA:
  - Remote Status.
  - Running Status.
  - Fault summary alarm.
  - Speed output of VFD (%).
  - Run control to VFD.
  - Speed control to VFD Third Level.
- The fault summary alarm deactivates the controls at the VFD and stops the pump. This alarm can be reset only at the VFD.
- In addition, displays for:
  - VFD Running.
  - VFD Failure.
  - VFD in PANEL (i.e., Keypad) or REMOTE (i.e., PLC or Local Control Station in LOCAL) mode.
  - Fault Reset pushbuttons have been provided on the VFD panel.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

Digester Feed Pumps:

- Each digester feed pump has a Local Control Station that consists of:
  - A LOCAL-REMOTE selector switch.
  - START and STOP pushbuttons.
  - Pump 1-OFF-Pump 2 selector switch (Digester Feed Pump 3 only).
- Switching the LOCAL-REMOTE selector switch to LOCAL will allow the START and STOP push buttons to start and stop the pump. Local speed control is set from the VFD.
- Switching the LOCAL-REMOTE selector switch to REMOTE allows control from either the VFD panel or the PLC.

  The PUMP 1-PUMP 2-OFF selector switch allows Digester Feed Pump 3 to be used in the place of either Pump 1 or 2.

Digester Feed Pump Discharge Manifold Control Valves:

- All local control is provided at each valve actuator.
- Operators select the operating mode via LOCAL-REMOTE (LR) selector at the valve actuator. Operation in each mode is described below:
    - LOCAL MODE:
        1. Place the LR selector in LOCAL position.
        2. The valve opens when the OPEN button is pressed.
        3. The valve closes when the CLOSE button is pressed.
    - REMOTE MODE:
        1. Place the LR selector in REMOTE position.
        2. The valve opens when a remote OPEN command is received from the SCADA system.
        3. The valve closes when a remote CLOSE command is received from the SCADA system.

SCADA Control Operation and Alarm Reset

SCADA Manual

Digester Feed Pumps:

- With the LOCAL/REMOTE selector at the Local Control Station in REMOTE, control from SCADA is enabled.
    - From SCADA, either MANUAL or AUTO control is selected.
    - In MANUAL, pumps can be started or stopped from SCADA icons.

Speed Control as % of maximum can also be set from SCADA while in MANUAL.

Digester Feed Pump Discharge Manifold Control Valves:

- Place the Valve LOCAL-REMOTE selector in REMOTE.
- Place the MANUAL-AUTO selector at the HMI graphics in MANUAL.
- Press the SCADA OPEN button to open the valve.
- Press the SCADA CLOSE button to close the valve.

SCADA Auto

Digester Feed Pumps:

- The LOCAL/REMOTE selector at the Local Control Station for digester feed pumps must be in the REMOTE position for SCADA control. From the SCADA Digester Feed Screen:
    - Select AUTO for each digester feed pump.
    - Turn the High Strength Feed Mode ON or OFF, if the High Strength Mode is OFF, SLUDGE ONLY Mode is ON).
    - If the High Strength Feed Mode is OFF a selector switch must be set to either Digester Feed Tank 1 or Digester Feed Tank 2 in order to choose the level transmitter that will be used to control the pump speed to maintain an 8-foot level in the active tank.

Digester Feed Pump Discharge Manifold Control Valves:

- In SCADA AUTO mode, the digester feed pump discharge manifold valves automatically open and close based on the Destination Complex and whenever Digester Feed Pump 1 or Pump 2 fails and Digester Feed Pump 3 is placed into service.
- Only DC2 In Service:
    - Digester Feed Pump Discharge Manifold Control Valve DC 1 - CLOSED.
    - Digester Feed Pump Discharge Manifold Control Valve Swing - OPEN.
    - Digester Feed Pump Discharge Manifold Control Valve DC 2 - OPEN.
- DC2 and DC1 In Service:
    - Digester Feed Pump Discharge Manifold Control Valve DC 1 - OPEN.
    - Digester Feed Pump Discharge Manifold Control Valve Swing - CLOSED.
    - Digester Feed Pump Discharge Manifold Control Valve DC 2 - OPEN.

Sludge Only Mode:

Any pump that is in auto will adjust its speed to maintain an 8 ft level in the active sludge tank. Normally only one pump will be in SCADA Auto. The pump speed will vary from 20% to 100% (~50-300 gpm). If the active tank falls below 3 feet a low-level interlock will stop the feed pump until the level of the active tank rises above 8 feet.

In Sludge only mode, feed to each digester will proceed sequentially in order of:
DC 1 DSHT 2 -> DC 1 DSHT 3 -> DC2 Dig 1 -> DC2 Dig 2 -> DC2 Dig 3. Each destination will have operator adjustable timer to adjust pump time. After time has expired, the next destination in sequence will begin.

Each complex will have operator selectable pump (Pump 1, 2, or 3) which will begin feeding when the sequence is calling for that complex.

When advancing in the sequence between complex's, the next digester feed valve will open and the current digester feed pump will stop. After the next digester feed valve is open, the current digester feed valve can close. Once the next digester feed valve is open, the next digester feed pump will start.

When advancing in the sequence within the same complex, the next digester feed valve will open, once open the current digester feed valve will close. Digester feed pumping does not stop.

High Strength Feed Mode *Currently Disabled*

DFT 2 will be the active sludge tank. Digester Feed Pump 1 will normally be used to feed sludge to the digesters as described for Sludge Only Mode.

DFT 1 will store the High Strength food waste. This waste will normally be fed to the digesters at an average rate of ~3.5 gpm. Feed Pump 2 will normally be used for the High Strength. It will operate at is minimum speed of 20%, delivering ~50 gpm when it is running. It will turn on for an operator

adjustable percentage (0-50%) of the feed cycle to each digester (e.g. if a digester has a 20 minute feed cycle time and the High Strength Feed Mode CYCLE % is set to 5.0%, the High Strength Feed Pump will run for 1 minute at the start of each Digester feeding cycle). If both digester feed valves are not online and in auto, the High Strength Feed Pump will operate on its own 20-minute cycle, turning on for a percentage of this time.

Digester Feed Pump 3 can operate as either Digester Feed Pump 1 or Digester Feed Pump 2. In High Strength Feed Mode, it if is selected to run as Feed Pump 1, it will only run if Feed Pump 1 is not running and therefore will serve as a backup pump.

SCADA Display

Status and Process Display

- HIGH STRENGTH/SLUDGE ONLY Modes.
- All Pumps: FIELD/SCADA.
- All Pumps: AUTO/MANUAL.
- All Pumps: Destination Complex.
- Each Digester (DC1 and DC2) Feed Time.
- Pump 3 Only: PUMP 1/PUMP 2/OFF.
- RUNNING status.
- FAULT summary alarm.
- % speed output of VFD.
- Digester Feed Tank 1 and 2 Level.
- Primary scum feed rate indication (0–300 gpm).
- Combined thickened sludge and primary scum fed rate indication to Digester Complex.
- For each digester feed pump discharge manifold valve:
    - Fully OPEN status.
    - Fully CLOSED status.
    - Valve in REMOTE mode.

Operator Entries

- HIGH STRENGTH MODE ON/OFF.
- All Pumps AUTO/MANUAL.
- All Pumps MANUAL SPEED SETPOINT (%).
- All Pumps: Destination Complex.
- Each Digester (DC1 and DC2) Sequence Feed Time.
- High Strength Mode FEED CYCLE %.
- SCADA MANUAL/AUTO selection for each digester feed pump discharge manifold valve.
- SCADA MANUAL OPEN and CLOSE buttons for each digester feed pump discharge manifold valve.

SCADA Alarms and Resets

- Digester Feed Flow Broken Transmitter (Brkn Xmtr).
- Digester Feed Pump Start FAIL.
- Digester Feed Pump Stop FAIL.
- Digester Feed Pump Pressure HI (90 psi).
- Digester Feed Pump FAULT.
- Digester Overflow Sump HIGH-HIGH.

Hard-Wired Interlocks

- HIGH discharge pressure stops a pump (hardwired to VFD) and is currently set at 90 psi.

Software Interlocks

- LOW-LOW level.
- In Sludge Only Mode, pumps will stop if the level in the active tank is below 3.0 feet and will automatically restart when the tank level rises to 8.0 feet.
- In any SCADA control mode pumps will stop if the level in their associated feed tank falls below 3.0 feet. This interlock prevents pumps from running dry and will be released when the level rises above 3.2 feet.
- Grinder Fail.
- Start Fail.
- Stop Fail.
- VFD Fail.
- If digester feed pump 3 is selected one of the digester feed pump discharge manifold valves must be open.
    - Destination Complex:
        - DC1: 710FV3812 must be OPEN.
        - DC2: 710FV3813 must be OPEN.

Historical Trending and Run-time Counters

- Feed rate and feed volume in gallons to each operating digester and to all digesters.
- Primary scum volume in gallons.
- Raw sludge flow to digesters.
- Digester Feed Tank 1 and 2 Levels.
- Digester Feed Pumps Speed.

Equipment Failure Sequence

- Digester Feed Pump 3 can be selected to run in place of Pump 1 or Pump 2.

Equipment Automatic Failover Sequence

- In High Strength Feed Mode if Digester Feed Pump 3 is selected for Pump 2, it will automatically run only if Pump 2 is not running when the High Strength Feed pump is called to run.

Equipment (Auto/Manual) Restart After Power Interruption

None.

END OF SUPPLEMENT

Control Loop Description	Digested Sludge Pumps (D60_140_CTL_040)

Process Description:

Digested sludge pumps transfer digested sludge from Digester Complex 2 Digesters 1, 2, 3, or digester overflow sump to digested sludge holding tanks located at Digester Complex 1. During normal operation, digested sludge overflows from digesters into overflow sump, where it is then pumped to Digested Sludge Holding Tank 1 (DSHT 1) for storage prior to dewatering. Pumps can pump directly to dewatering centrifuges in the event DSHT 1 is out of service. They can also pump from bottom of Digester 1, 2, or 3 for maintenance operations that require emptying a digester.

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
20P10501	Digested Sludge Pump 1	
20P10502	Digested Sludge Pump 2	
NA	Overflow Sump	

Instrumentation:

Tag No.	Description	Notes
20FIT10501	Digested Sludge Pump Flow Transmitter	
20LIT10601	Overflow Sump Level Indicating Transmitter	

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- At the VFD, a display panel is provided to monitor the operating parameters. A keypad is provided to allow manual adjustment of START, STOP, and speed control functions from the VFD when LOCAL is selected at the pump. The following signals are monitored or controlled by SCADA via Ethernet communication:
  - Remote Status.
  - Running Status.
  - Fault summary alarm.
  - Speed output of VFD (in %).
  - Run control to VFD.
  - Speed control to VFD.
- The fault summary alarm deactivates the controls at the VFD and stops the pump. This alarm can be reset only at the VFD.
- In addition, displays for VFD Running, VFD Failure, VFD in PANEL (i.e., Keypad) or REMOTE (i.e., PLC or Local Control Station in LOCAL) mode, and Fault Reset pushbuttons have been provided on VFD panel.

Motor Control Center

- None

MFR Control Center

- None

Local Control Station

- The local control panel at each pump has:
  - A LOCAL/REMOTE selector switch
  - START and STOP pushbuttons
  - In LOCAL mode, the pumps can be started or stopped.
    - Note - local speed control is from VFD only.

SCADA Control Operation and Alarm Reset

SCADA Manual

- With the LOCAL/REMOTE selector at Local Control Station switch in REMOTE, control is from SCADA.
  - With the SCADA AUTO/MANUAL selector in MANUAL, the pumps are controlled by the popups on the SCADA display.
  - In destination DEWATERING CENTRIFUGES, proper flowmeter for display on centrifuge screen is established. Interlocks are set to stop pump on centrifuge FAIL.
  - In destination HOLDING TANK 1, interlocks are set to stop pump on digested sludge storage tank 1 HIGH LEVEL.

SCADA Auto

- With the LOCAL/REMOTE selector at Local Control Station switch in REMOTE, control is from SCADA.
- Pumping to Digested Sludge Holding Tank 1:
  - A LOW LEVEL of 7.0 feet in the digester overflow sump will stop the pump(s).
  - A level of 12.0 feet will start the lead pump.
  - A HIGH LEVEL of 14.0 feet will start the lag pump.
- The operator must manually reset or change the duty pump to continue pumping if a pump running in AUTO fails.

SCADA Display
Status and Process Display
• Pump stopped/running status. • Field/SCADA status. • Sludge flow rate. • Flow totalizer for each day of week as well as for entire week. These flow totalizers are reset automatically at the beginning of each week. (Sunday 00:00:00 a.m.)
Operator Entries
• Level setpoint (initially set at 10 feet) • Selection of DSHT 1/Dewatering Centrifuge Feed.
SCADA Alarms and Resets
• Level alarms. • HIGH-HIGH at 14.5 feet (Zetron). • HIGH at 14.0 feet. • LOW at 5.0 feet. • Both pumps running (Zetron). • Both Pumps running for 15 minutes (Zetron). • Pump fault. • External faults (low flow, high pressure). • The fault summary alarm deactivates the controls at the VFD and stops the pump. This alarm can be reset only at the VFD by cycling power.
Hard-Wired Interlocks
• HIGH discharge pressure (100 psi) will stop pump.
Software Interlocks
• A LOW LEVEL condition (5.0 feet) in digester overflow sump will stop the pumps. • Pump discharge low flow condition.
Historical Trending and Run-time Counters
• Sludge flow. • Digested Sludge Sump Level.
Equipment Failure Sequence
None.
Equipment Automatic Failover Sequence
None.
Equipment (Auto/Manual) Restart After Power Interruption
None.

END OF SUPPLEMENT

Control Loop Description	Digester Complex 2 Digester Feed Valves (D60_110_CTL_060)

Process Description:

Digester feed valves are motorized valves located at digester feed manifold in Digester Complex 2 (DC 2). Valves open to direct sludge feed flow to the selected digester. Automatic operation is a timed-cycle alternation between available digesters.

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
750FV3801	DC2 Digester 1 Feed Valve	
750FV3801-LCS	DC2 Digester 1 Feed Valve Local Control Station	
750FV3802	DC2 Digester 2 Feed Valve	
750FV3802-LCS	DC2 Digester 2 Feed Valve Local Control Station	
725FV3801	DC2 Digester 3 Feed Valve	
725FV3801-LCS	DC2 Digester 3 Feed Valve Local Control Station	

Instrumentation:

Tag No.	Description	Notes

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- None.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

- All local control is provided at each valve actuator.
- Operators select the operating mode via LOCAL-REMOTE (LR) selector at the valve actuator. Operation in each mode is described below:
    - LOCAL MODE:
        1. Place the LR selector in LOCAL position.
        2. The valve opens when the OPEN button is pressed.
        3. The valve closes when the CLOSE button is pressed.
    - REMOTE MODE:
        1. Place the LR selector in REMOTE position.
        2. The valve opens when a remote OPEN command is received from the SCADA system.
        3. The valve closes when a remote CLOSE command is received from the SCADA system.

SCADA Control Operation and Alarm Reset

SCADA Manual

- Place the Valve LOCAL-REMOTE selector in REMOTE.
- Place the MANUAL-AUTO selector at the HMI graphics in MANUAL.
- Press the SCADA OPEN button to open the valve.
- Press the SCADA CLOSE button to close the valve.

SCADA Auto

- In SCADA AUTO mode, the digester feed valves automatically open and close whenever DC2 is selected to receive sludge.
- If only one DC2 digester is selected online, then the associated feed valve is commanded OPEN and left OPEN.
- When more than one digester is selected online (three now, up to four in the future), then valves are opened and closed in a timed sequence. The Operator enters a time interval for the digester feed. Starting with DC2 Digester 1, the associated valve is opened for this time period. When the time has elapsed, the valve for the DC2 Digester 2 is commanded to OPEN. When the Digester 2 feed valve is fully opened, the Digester 1 valve is commanded to CLOSE. When the time has elapsed, the valve for the DC2 Digester 3 is commanded to OPEN. When the Digester 3 feed valve is fully opened, the Digester 2 valve is commanded to CLOSE. When the Digester 3 valve has been opened for the time period, the cycle repeats with Digester 1.

SCADA Display

Status and Process Display

- For each digester feed valve:
  - Fully OPEN status.
  - Fully CLOSED status.
  - Valve in REMOTE mode.

Operator Entries

- SCADA MANUAL/AUTO selection for each valve.
- SCADA MANUAL OPEN and CLOSE buttons for each valve.
- DC2 sludge feed ONLINE/OFFLINE selection.
- DC2 Digester 1 ONLINE selection.
- DC2 Digester 2 ONLINE selection.
- DC2 Digester 3 ONLINE selection.
- Digester feed sequence TIME interval, adjustable from 5 to 60 minutes.

SCADA Alarms and Resets

- If any one of the digester feed valves do not open provide a Digester Feed Valve FAIL TO OPEN alarm.

Hard-Wired Interlocks

- None.

Software Interlocks

- When all DC2 digester feed valves are fully closed, signal selected digester feed pump and grinder to Stop.

Historical Trending and Run-time Counters

- None.

Equipment Failure Sequence

- None.

Equipment Automatic Failover Sequence

- None.

Equipment (Auto/Manual) Restart After Power Interruption

- None.

END OF SUPPLEMENT

Control Loop Description	DC2 Control Room Air Handling Unit

Process Description:

An air handling unit (AHU) located in the penthouse of Digester Complex 2 (DC2) supplies air to the DC2 Control Room. The AHU heats or cools the space to maintain a room temperature.

Cooling is provided by an outdoor mounted, refrigerant condensing unit and heating is provided by a hot water coil supplied with heated water from the hot water loop.

System will be controlled by a thermostat. System operation will be controlled by an OFF-HEAT-AUTO-COOL system switch and an AUTO-ON fan switch.

System will be in economizer mode when cooling is required and the outside air is suitable for cooling (less than 65 degrees F). Outside air is suitable for cooling when the outside air temperature is below the changeover temperature. The control will modulate the outside air and return air to maintain room temperature.

Low Temperature Setpoint: 40 degrees F
Heating Temperature Setpoint: 50 degrees F
Cooling Temperature Setpoint: 75 degrees F
High Temperature Alarm Setpoint: 90 degrees F

Reference Drawing(s):			
Last Update/Review:	08/2025	**Approved By:**	

Equipment

Unit Equipment:

Tag No.	Description	Notes
725AHU5001	Air Handling Unit	
725ACU5001	Condensing Unit	
	Hot Water Control Valve	

Instrumentation:

Tag No.	Description	Notes
725TIC5001	Thermostat	
725TT9601	DC2 Control Room Ambient Temperature	
	Outside Air Temperature	

Control Strategies

Local Control Operation and Alarm Reset

VFD Control Panel

- None.

Motor Control Center

- None.

MFR Control Center

- None.

Local Control Station

- None.

SCADA Control Operation and Alarm Reset

SCADA Manual

- None.

SCADA Auto

- None.

SCADA Display

Status and Process Display

- Fan Status.
- DC2 Control Room Ambient Temperature.

Operator Entries

- None.

SCADA Alarms and Resets

- Fan FAULT.
- DC2 Control Room ambient temperature is greater than 90 degrees F.

Hard-Wired Interlocks

- None.

Software Interlocks

- None.

Historical Trending and Run-time Counters

- Fan run time.
- Room temperature.

Equipment Failure Sequence

- None.

Equipment Automatic Failover Sequence
• None.
Equipment (Auto/Manual) Restart After Power Interruption
Air handling unit to restart automatically when power is restored.

END OF SUPPLEMENT

SECTION 17208
LEVEL MEASUREMENT: RADAR

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Non-contact radar.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definition:

1. PTOF: Pulse Time of Flight.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

C. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

D. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Non-Contact Radar (Solids):

1. One of the following:
   a. Endress + Hauser; Micropilot FMR67B.
   b. VegaPuls; 6X Series.
   c. "Or-equal."

B. Non-Contact Radar (Liquids):

1. One of the following:
   a. Endress + Hauser; Micropilot FMR62B, PTFE Cladded, dual compartment.
   b. VegaPuls; 6X Series.
   c. “Or-equal.”

C. Remote Indication:

1. One of the following:
   a. Endress + Hauser; FHX-50B.
   b. Vega; DIS-81.
   c. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Measurement Signal:

1. General:
   a. Instrument emits radar signal or microwave pulses, with a frequency range of 6.3 GHz, 26 GHz to 80 GHz. Frequency selection based on application.
   b. Safety: Shall not generate frequency waves with power levels hazardous to humans.
2. Performance Requirements:
   a. Accuracy Level: Plus or minus 0.25 inch.
3. Element:
   a. Level element must conform to the process material compatibility as indicated on the Instrument Data Sheets or the Instrument Index.
   b. Connections:
      1) Process: The antenna design shall be suitable for mounting in a nozzle as indicated on the Instrument Data Sheets or the Instrument Index.
      2) The design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between either parabolic-shaped, cone-shaped, rod-shaped antennas.
4. Transmitter:
   a. Microprocessor-based signal converter or transmitter.
   b. Power Supply:
      1) 24V dc, two-wire loop-powered.
      2) Power Consumption: 15 VA maximum.

c. Outputs: Isolated 4 mA dc to 20 mA dc with HART communication protocol.
d. Backlit digital display for level or volume.
e. Bluetooth enabled.
f. Self-diagnostics and Automatic Data Checking: Heartbeat verification.
g. Signal Integrity:
    1) Immune to radio frequency and electromagnetic interference with field strength of 15 volts or meter or less over a frequency range of 50 Hz to 460 MHz.
    2) Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
h. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
    1) Indication: Local segment display with Bluetooth.
i. Instruments Shall be Explosion Proof: Class I, Division 1 and 2, Group A, B, C, and D.
    1) Rated without intrinsic barrier required.
j. Electrical connection: 1/2-inch male NPT.

5. Transmitter Mounting: Flanged, 8-inch.

2.03 ACCESSORIES

A. Software: Provide Windows based PC software for configuration and echo mapping.

B. Provide sun shield for transmitters located in outdoor installations.

1. Face north if possible.
2. Manufacture:
    a. Instrument manufacturer’s sun shield.
    b. Intertec DIASHADE SD 67.
    c. “Or-equal.”

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each level transmitter at a facility that is traceable to NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. Example Instrument Data Sheet template included after end of this section.

B. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

3.08 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:			**RADAR PT OF LEVEL INSTRUMENTS**							
							Spec. No.			**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**	17208			
Project:	Digester Phase 6B						**Contract**			**Date**
Customer:	Clean Water Services									
Plant:	Durham WRRF						**Req.**			**P.O.**
Location:	Tigard, OR									
BOM No.:							**By**	**Chk**		**App**
File:										
G	**1**	**Instrument Tag Number**								
E	**2**	**Service**								
N	**3**	**P&ID**								
	4	**Other**								
	5	**Type**								
P	**6**	**Housing Material**								
R	**7**	**Measurement Range**								
O	**8**	**Op. Temp. Range**								
B	**9**	**Manufacturer**								
E	**10**	**Model**								
	11	**Model Number**								
	12	**Antenna Style**								
	13	**Other**								
	14	**Other**								
	15	**Other**								
	16	**Other**								
	17	**Type**								
T	**18**	**Operating Mode**								
R	**19**	**Enclosure**								
A	**20**	**Mounting**								
N	**21**	**Temperature Range**								
S	**22**	**Voltage Requirements**								
M	**23**	**Power**								
I	**24**	**Accuracy**								
T	**25**	**Calibrated Range**								
T	**26**	**Display**								
E	**27**	**Output**								
R	**28**	**Calibration**								
	29	**Status Relay**								
	30	**Manufacturer**								
	31	**Model No.**								
	32	**Damping**								
	33	**Elect. Entry**								
	34	**Other**								
O	**35**									
P	**36**									
T	**37**									
S	**38**									
Notes:										

SECTION 17305
FLOW MEASUREMENT: THERMAL MASS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:

1. Thermal mass flow measurement for permanent installations.

B. Related Sections: The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated Project.

C. Furnish all instruments identified on the P&IDs, instrument lists, and instrument data sheets.

1.02 REFERENCES

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Refer to Section 17901, Instrument List, for calibration and other requirements.

1.03 DEFINITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Retract Mechanism: A device, which holds the sensor probe in place for the flow measurement. This device also includes a mechanism, which enables the plant maintenance staff to remove the probe easily for cleaning and other maintenance need. This device also enables the plant maintenance staff to re-insert the sensor probe back into its original position without leakage for measurement service again.

C. Surface Mount Technology: The practice and method of attaching leaded and non-leaded electrical components to the surface of a conductive pattern that does not utilize leads in feed through holes. This technology reduces power requirements for the thermal flow instruments.

1.04 SUBMITTALS

A. Furnish complete submittals in accordance with Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Furnish complete Product Data Sheets in ISA form, Shop Drawings, Test Reports, Operating and Installation Manuals, Record Drawings, Manufacturer's Field Reports, and other submittals in the format as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Additional Requirements: Provide operating procedures for the probe retract mechanism.

1.05 QUALITY ASSURANCE

A. Thermal mass flow meters shall be factory calibrated on an approved test stand with certified accuracy traceable to NIST.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Store all instruments in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the manufacturer:

1. Replace instruments that are not stored in strict conformance with the manufacturer's recommendation shall be replaced.

C. Pack the retract mechanism with proper identification label with its own assembly instruction manual.

1.07 PROJECT OR SITE CONDITIONS

A. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, process and ambient temperature and humidity conditions.

B. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, for Project environmental conditions.

1.08 WARRANTY

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. In addition to the requirements of Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, provide Manufacturer's warranty for each instrument for a period of 1 year after Project substantial completion.

1.09 MAINTENANCE

A. Provide all parts, materials, fluids, etc. necessary for maintenance and calibration purposes throughout the warranty period. Deliver all of these supplies before Project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Flow Measurement Gas/Air:

1. Fluid Component Inc. (FCI); Model No. ST100A Series.
2. Sierra Instruments; BioTrak 645i/745i Series.
3. KURZ; 454FTB-WGF Series.
4. No substitutions allowed.

2.02 MANUFACTURED UNITS

A. General:

1. Insertion thermal mass flow meter shall be able to measure air flow, industrial, and process gas mass flows by detecting the heat transfer from a heated RTD sensor referenced to the temperature of the ambient gas stream sensor. The electronic circuitry shall either maintain a constant differential temperature between the gas temperature and the heated element or a constant power. The electronic circuitry shall deliver a linear signal 4 mA dc to 20 mA dc output proportional to the process fluid flow.
2. Thermal mass flow switches shall be able to measure water flow and shall be calibrated to open a dry contact above the calibrated range and close the dry contact below the calibrated range.
3. Thermal mass flow meters shall include self-checking calibration validation acceptable for DEQ requirements including validation documentation.

4. Each thermal mass flow system shall include:
   a. RTD sensor(s).
   b. Signal cable.
   c. 4 mA to 20 mA signal output with HART Protocol
   d. Remote or local mounted transmitter to be FM approved or UL listed for the appropriate electrical area classification.
   e. A balance retract mechanism or hot tap installation for removing and insertion of the probe sensor assembly.
   f. Flow Element Sensor with Terminal Enclosure:
      1) Constructed of NEMA 4X cast aluminum housing.
      2) Utilize a Type 316 stainless steel sensor.
      3) No overheat at zero flow.
   g. Remote Mount Transmitter:
      1) Microprocessor-based signal converter/transmitter.
      2) Enclosure shall be NEMA 4X.
   h. Isolated 4 milliamperes to 20 milliamperes direct current into 650 ohm load without need for external load adjustments. Linearly proportional to measured level range proportional to tank or vessel volume instead of level where indicated.
      1) Contain an alphanumeric display for flow rate.
      2) Ambient operating temperature limits of 0 degree F to 150 degrees F.
   i. Signal Cable between Sensor Head and Transmitter:
      1) Transmitter shall be able to install 500 feet away from the sensor head assembly without impact on performance and accuracy.
      2) Provide adequate signal cable as shown on the Drawings plus extra 6 feet long (coil it up for future need).
      3) PVC jacketed or compatible cable for digester gas.
   j. Performance Requirements:
      1) Time Constant: 1 second to 50 seconds.
      2) Accuracy: 1.5 percent of full scale for velocities over 2 feet per second.
      3) Repeatability: 0.5 percent of full scale.
   k. Power Supply:
      1) 120 V ac plus or minus 10 percent.
      2) 60 Hz.
      3) 3 Watts maximum.

2.03 ACCESSORIES

A. Provide a balance retract mechanism for insertion and retraction of the probe sensor assembly.

B. Software (if available as either a standard or an option) for full validation of instrument performances.

C. Provide rain-hood and sun shield to minimize glare and effects from UV.

D. Provide sun shield for outdoor installations.

E. Provide isolation valves on insertion of probe sensor assembly for air service measurements.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, and noted herein.

B. Factory calibrate each thermal mass flow metering system at a facility that is traceable to the Nation Institute of Testing Standards, using the same medium, as the instrument will be measuring in the field.

C. A real-time computer generated printout of the actual calibration data indicating apparent and actual flows at 0 percent, 25 percent, 50 percent, 75 percent, 100 percent, 75 percent, 50 percent, 25 percent and 0 percent (a 9-point calibration in both ascending and descending directions) of the calibrated range shall be submitted to the Engineer at least 30 days before shipment of the meters to the Project Site.

D. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

B. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 PREPARATION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 INSTALLATION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.04 FIELD QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Site Test and Inspection: Perform installed tests in accordance with Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Demonstrate the performance of all instruments to the Engineer before commissioning.

D. Engineer to witness all instrument calibration verification in the field.

E. Each instrument shall be tested before commissioning and the Engineer shall witness the response in the PLC control system and associated registers.

F. Manufacturer’s Field Services: Manufacturer authorized technician shall inspect and approve each flowmeter installation.

3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the Manufacturer’s instructions.

B. Perform any supplemental calibration specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 CLEANING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 DEMONSTRATION AND TRAINING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 PROTECTION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. All instruments shall be fully protected after installation and before commissioning. The Contractor shall replace any instruments damaged before commissioning:

1. The Engineer shall be the sole party responsible for determining the corrective measures.

3.09 SCHEDULES

A. See the schedule included with Section 17901, Instrument List, for additional information.

B. Produce completed Instrument Data Sheets for all instruments required under this Contract:

1. See Section 17050, Basic Measurement and Control Instrumentation Materials and Methods, for additional requirements.
2. Submit all Instrument Data Sheets for review.
3. Furnish Instrument Data Sheets in hard copy format.

C. Example Instrument Data Sheet template included after end of this section.

3.10 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		THERMAL MASS FLOWMETERS				INSTRUMENT DATA SHEETS		
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	17305		
Project:	Digester Phase 6B					Contract		Date
Customer:	Clean Water Services							
Plant:	Durham WRRF					Req.		P.O.
Location:	Tigard, OR							
BOM No.:						By	Chk	App
File:								

	1	Instrument Tag No.										
	2	Service										
	3	P&ID										
ELEMENT	4	CONN	Line Size / Schedule									
	5		Line Material									
	6		Connection Type/Pressure Rating									
	7		Connection Materials									
	8	METER	Sensor Length									
	9		Sensor Material									
	10		Sensor Type									
	11		Power Supply	Phase								
	12		Grounding Type & Matl.									
	13		Enclosure Class									
	14		Other									
	15	FLUID	Fluid									
	16		Max Flow									
	17		Min Velocity									
	18		Min Flow	Norm Flow								
	19		Min Temp	Max Temp								
	20		Min Press	Max Press								
	20		Reverse Flow Possibility									
	21		Oher									
TRANSMITTER	22	Function										
	23	Mounting										
	24	Enclosure Class										
	25	Length Signal Cable										
	26	Type Span Adjustment										
	27	Power Supply										
	28	Transmitter Output										
	29	Relay Outputs										
	30	Accuracy										
	31	Calibrated Range										
	32	Empty Pipe Detection										
	33	Bi-Directional Flow										
	34	Display Scale Size	Range									
	35	Alarm Contact No.	Form									
	36	Manufacturer										
	37	Element (Meter) Model No.										
	38	Transmitter (Inst.) Model No.										

Notes:

SECTION 17310
FLOW MEASUREMENT: ULTRASONIC TIME OF FLIGHT (TOF) FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Clamp-on ultrasonic doppler flowmeters.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

C. Provide all instruments identified on the Drawings.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

B. NSF International (NSF): Certified Products and Systems.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330, Submittal Procedures and Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Clamp-On Ultrasonic Flow Meter:

1. One of the following:
   a. Flexim; Fluxus F721.
   b. Endress+Hauser; Prosonic Flow 91W.
   c. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Clamp-on Ultrasonic Flowmeter:

1. General:
   a. Ultrasonic flowmeters obtain the flow velocity by measuring the transit time difference of ultrasonic pulses sent through the flowing media in the upstream and downstream directions.
   b. Include for Each Ultrasonic Flow Metering System:
      1) A pair of ultrasonic transmitting/receiving sensors.
      2) Mounting hardware and material for installation on existing pipe systems.
      3) Signal cable.
      4) Transmitter remote for wall mounting.
2. Performance Requirements:
   a. Accuracy: 1 percent of flow rate from 10 percent to 100 percent of full scale for velocities ranging between 0.5 foot to 10 feet per second.
   b. Repeatability: 0.15 percent of rate, plus or minus 0.002 feet per second.
3. Element:
   a. Frequency: Available in range from 0.2 MHz to 8 MHz. Select frequency that provides best results based on pipe diameter and wall thickness.
   b. Ambient Temperature: Minus 13 degrees F to plus 140 degrees F.
   c. Process Temperature: Minus 4 degrees F to plus 176 degrees F.
   d. Mounting Hardware: Track, clamps, and coupling pads designed to provide aligned and acoustically-coupled connection to outside of existing pipe.
   e. Cable: Integrated with sensor with length as required for connection to remote mounted transmitter.

4. Transmitter:
   a. Power Supply:
      1) 120V ac.
      2) Power consumption: 20 VA maximum.
   b. Outputs: 4 mA to 20 mA proportional to flow rate, with HART protocol.
   c. Microprocessor-based signal converter/transmitter.
   d. Contain a 6-digit display for flow rate, percent of span, and totalizer.
   e. Programmable Parameters Including:
      1) Pipe size.
      2) Pipe wall thickness.
      3) Full-scale flow rate.
   f. Data retention for a minimum of 5 years without auxiliary main or battery power.
   g. Self-diagnostics and automatic data checking.
   h. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
   i. Ambient operating temperature limits of minus 5 degrees F to 140 degrees F (minus 20 degrees C to 60 degrees C).
   j. Enclosure: Rated NEMA 4X, suitable for damp and wet locations. Provide with hazardous area rating if located in classified area.

2.03 ACCESSORIES

A. Stainless steel tag labeled as specified in the Contract Documents.

B. Provide sunshades for all transmitters located outdoors.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

B. Factory calibrate each flow metering system at a facility that is traceable to the NIST.

C. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values.

1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

B. Provide manufacturer’s services to perform installation inspection, configuration, and testing.

3.03 ADJUSTING

A. Measure existing pipe diameter and wall thickness and calibrate flow reading for field-measured values.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Material and Methods.

3.07 SCHEDULES

A. Instrument Data Sheets included in this section.

B. The provided information does not necessarily include all required instruments.

C. Provide all instruments identified in the Contract Documents: Instruments may be indicated on the Drawings, specified in the Specifications, or both.

3.08 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		ULTRASONIC TOF FLOWMETERS				INSTRUMENT DATA SHEETS		
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	**17310**		
Project:	Digester Phase 6B					Contract		Date
Customer:	Clean Water Services							
Plant:	Durham WRRF					Req.		P.O.
Location:	Tigard, OR							
BOM No.:						By	Chk	App
File:								

	1	Instrument Tag No.										
	2	Service										
	3	P&ID										
ELEMENT	4	CONN	Line Size / Schedule									
	5		Line Material									
	6		Connection Type/Pressure Rating									
	7		Connection Materials									
	8	METER	Sensor Length									
	9		Sensor Material									
	10		Sensor Type									
	11		Power Supply	Phase								
	12		Grounding Type & Matl.									
	13		Enclosure Class									
	14		Other									
	15	FLUID	Fluid									
	16		Max Flow									
	17		Min Velocity									
	18		Min Flow	Norm Flow								
	19		Min Temp	Max Temp								
	20		Min Press	Max Press								
	20		Reverse Flow Possibility									
	21		Oher									
TRANSMITTER	22	Function										
	23	Mounting										
	24	Enclosure Class										
	25	Length Signal Cable										
	26	Type Span Adjustment										
	27	Power Supply										
	28	Transmitter Output										
	29	Relay Outputs										
	30	Accuracy										
	31	Calibrated Range										
	32	Empty Pipe Detection										
	33	Bi-Directional Flow										
	34	Display Scale Size	Range									
	35	Alarm Contact No.	Form									
	36	Manufacturer										
	37	Element (Meter) Model No.										
	38	Transmitter (Inst.) Model No.										

Notes:

SECTION 17311
FLOW MEASUREMENT: ULTRASONIC DOPPLER FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Clamp-on ultrasonic doppler flowmeters.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all instruments identified on the Drawings.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. NSF International (NSF): Certified Products and Systems.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Clamp-On Ultrasonic Doppler Flow Meter:

1. One of the following:
   a. Pulsar; DFM Series 6.1.
   b. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Clamp-on Ultrasonic Flowmeter:

1. General:
   a. Ultrasonic flowmeters obtain the flow velocity by measuring based on the doppler effect.
   b. Include for each ultrasonic flow metering system:
      1) Transducer.
      2) Mounting hardware and material for installation on existing pipe systems.
      3) Signal cable.
      4) Transmitter remote for wall mounting.
2. Performance Requirements:
   a. Accuracy: Plus or minus 2 percent of reading or 0.03 meters per second (0.1 feet per second) whichever is greater. Requires solids or bubbles minimum size of 100 microns, minimum concentration 75 ppm.
   b. Repeatability: Plus or minus 0.1 percent.
3. Element:
   a. Flow Range: 0.1 foot per second to 40 feet per second.
   b. Frequency: Select frequency that provides best results based on pipe diameter and wall thickness.
   c. Operating Temperature: Minus 40 degrees F to 300 degrees F.
   d. Mounting Hardware: Track, clamps, and coupling pads designed to provide aligned and acoustically-coupled connection to outside of existing pipe.
   e. Cable: Integrated with sensor with length as required for connection to remote mounted transmitter.
4. Transmitter:
   a. Power Supply:
      1) 120V ac.
      2) Power Consumption: 20 VA maximum.

b. Outputs:
   1) 4 mA to 20 mA proportional to flow rate with HART.
   2) Minimum of one control relay.
c. Microprocessor-based signal converter/transmitter.
d. Contain a backlit display for flow rate, percent of span, and totalizer.
e. Programmable Parameters Including:
   1) Pipe size.
   2) Pipe wall thickness.
   3) Full-scale flow rate.
f. Data retention for a minimum of 10 million point logger with USB output.
g. Self-diagnostics and automatic data checking.
h. Ambient operating temperature limits of minus 10 degrees F to 140 degrees F (minus 23 degrees C to 60 degrees C).
i. Enclosure: Rated NEMA 4X, suitable for damp and wet locations. Provide with hazardous area rating if located in classified area.

2.03 ACCESSORIES

A. Stainless steel tag labeled as specified in the Contract Documents.

B. Provide sunshades for all transmitters located outdoors.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each flow metering system at a facility that is traceable to the NIST.

C. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values.

1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
2. Minimum calibration shall be a three point calibration including 1 foot, 3 feet, and 10 feet per second velocities for every meter and transmitter system.
3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform installation inspection, configuration, and testing.

3.03 ADJUSTING

A. Measure existing pipe diameter and wall thickness and calibrate flow reading for field-measured values.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. Example Instrument Data Sheet template included after end of this section.

B. The provided information does not necessarily include all required instruments.

3.08 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		ULTRASONIC DOPPLER FLOWMETERS				INSTRUMENT DATA SHEETS		
						Spec. No.		Rev.
Contractor:		No	By	Date	Revision	17311		
Project:	Digester Phase 6B					Contract		Date
Customer:	Clean Water Services							
Plant:	Durham WRRF					Req.		P.O.
Location:	Tigard, OR							
BOM No.:						By	Chk	App
File:								

	1	Instrument Tag No.										
	2	Service										
	3	P&ID										
ELEMENT	4	CONN	Line Size / Schedule									
	5		Line Material									
	6		Connection Type/Pressure Rating									
	7		Connection Materials									
	8	METER	Sensor Length									
	9		Sensor Material									
	10		Sensor Type									
	11		Power Supply	Phase								
	12		Grounding Type & Matl.									
	13		Enclosure Class									
	14		Other									
	15	FLUID	Fluid									
	16		Max Flow									
	17		Min Velocity									
	18		Min Flow	Norm Flow								
	19		Min Temp	Max Temp								
	20		Min Press	Max Press								
	20		Reverse Flow Possibility									
	21		Oher									
TRANSMITTER	22	Function										
	23	Mounting										
	24	Enclosure Class										
	25	Length Signal Cable										
	26	Type Span Adjustment										
	27	Power Supply										
	28	Transmitter Output										
	29	Relay Outputs										
	30	Accuracy										
	31	Calibrated Range										
	32	Empty Pipe Detection										
	33	Bi-Directional Flow										
	34	Display Scale Size	Range									
	35	Alarm Contact No.	Form									
	36	Manufacturer										
	37	Element (Meter) Model No.										
	38	Transmitter (Inst.) Model No.										

Notes:

SECTION 17316
ROTAMETERS (VARIABLE AREA FLOW METERS)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for: Rotameters (variable area flow meters).

B. Related Sections: The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Refer to Section 17901, Instrument List for calibration and other requirements.

1.03 DEFINITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Blue-White F-440 Series for indoor applications.
2. Blue-White F-550 Series for outdoor applications.
3. No exceptions.

2.02 MANUFACTURED UNITS

A. Rotameters:

1. General: Variable area type flow meters with local flow indication.
2. Performance Requirements:
   a. Flow Range: As listed in Instrument List.
   b. Accuracy:
      1) Plus or minus 5 percent of range.
      2) Repeatability: 0.50 percent of range.
3. Element:
   a. Flow Tube:
      1) Indoor Application: Polysulfone, or as required to be compatible with the process conditions.
      2) Outdoor application:
         a) Acrylic or glass. Rated for outdoor use.
         b) Suitable for direct sunlight exposure.
   b. Process Temperature: maximum 200 degrees F.
   c. Maximum Process Pressure: 200 psig.
   d. Float: 316 SS with integrated guide rod.
4. Components:
   a. Seals: Viton seals.
   b. Integral needle valve for flow control.
5. Other:
   a. Process Connection: As indicated on the Mechanical Drawings.
   b. Mounting:
      1) As indicated on the Drawings.
      2) Provide all necessary hardware for rotameter mounting.

2.03 SOURCE QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the ENGINEER before commissioning.

3.06 PROTECTION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be shown on the Drawings, in the Specifications or both.

3.08 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		FLOW ROTAMETER							
						Spec. No.		Rev.	
Contractor:		No	By	Date	Revision	17316			
Project:	Digester Phase 6B					Contract		Date	
Customer:	Clean Water Services								
Plant:	Durharm WRRF					Req.		P.O.	
Location:	Tigard, OR								
BOM No.:						By	Chk	App	
File:									

1	Type	Direct Rdg.:		Receiver:		Other:
2	Mounting	Not required:		Front Panel:		Flush:
3	Readout	Scale:			Color:	
4	Fitting Material	Brass/Bronze:	316 SS:	PVC:	Other:	Other:
5	Connection Designation	H Thread:	H Flange:	V Thread:	V Flange:	Other:
6	Blowout Protection	None:	Disc:	Front:	Other:	Mfr. Std.
7	Seals	O-Rings:			Packing:	
8	Options	Option1:			Material:	
9	Other	Option2:				
10	Other	Pressure Limit Valve: N/A				
11	Other	Movement Damping: N/A				
12	Nominal Accuracy Required					
13	Size	Connection Size:		Tube Size:		Other:
14	Element Material	Bronze:	Steel:		Type SS:	Other:
15	Connection Type	NPT:	Flat Face:		Raised Face:	Other:
16	Connection	¼ in.:	½ in.:		Bottom:	Other:
17	Movement	Dampened:	Standard:		Other:	
18	Alarms	Not Required:		Other:		Type:
19	Other	Other Mat'l:		Fill Fluid:		Model:
20	Manufacturer					
21	Model No.					

Rev	Tag Number	Range	P&ID	Service	Notes

Notes:
Refer to Section 17402 for additional instrument valve requirements.

SECTION 17401
PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Diaphragm seals.
2. In-line saddle diaphragm seals.
3. Annular seals.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Refer to Section 17901, Instrument List, for other requirements.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data:
   a. Manufacturer’s installation instructions.
   b. Seal type.
   c. Body materials.
   d. Diaphragm material.
   e. Fill fluid type.
   f. Seal size.
   g. Options.
   h. Process connection.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Diaphragm Seals:

1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge:
   a. One of the following:
      1) Ashcroft; Type 741.
      2) Mansfield and Green; Type SGT.
      3) Wika; Type L990.40.
      4) Rosemount; 1199.
      5) ReoTemp.
      6) “Or-equal.”

B. In-Line Saddle Weld Diaphragm Seal:

1. Ashcroft; 206.
2. No exceptions.

2.02 MANUFACTURED UNITS

A. Diaphragm Seals:

1. General: Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
2. Requirements:
   a. Seal Type:
      1) Metallic Diaphragm: Welded to upper housing.

b. Process Connection: 1-inch NPT.
c. Instrument Connection: 1/2-inch NPT.
d. Material Construction: Type 316 stainless steel.
e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
f. Flush Port Plug: Same material of construction as diaphragm lower housing.
g. Provide fill/bleed connection.
h. Mounting: As indicated in the Contract Documents.
i. Provide Type 316 stainless steel armored capillary for all remote installations.
j. Nuts and Bolts: Type 316 stainless steel.
k. Materials of Construction:
    1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
        a) Diaphragm: Type 316 stainless steel.
        b) Lower Housing: Type 316 stainless steel.
        c) Upper Housing: Manufacturer's standard.
        d) Fill Fluid: Silicon oil.
    2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
        a) Diaphragm: Type 316 stainless steel.
        b) Lower Housing: Type 316 stainless steel.
        c) Upper Housing: Manufacturer's standard.
        d) Fill Fluid: Silicon oil.
    3) Engineer's approval.

B. In-Line Saddle Diaphragm Seal:

1. General:
    a. Process Connections:
        1) 1/2-inch to 3-inch pipe.
            a) Lower Housing: In-line flanged.
            b) Diaphragm welded to top housing.
            c) Diaphragm Material: Type 316L stainless steel.
            d) Bottom Housing Material: Type 316L stainless steel.
            e) Instrument Connection Size: 1/4-inch or 1/2- inch NPT.
            f) Fluid Fill: Acceptable to corresponding process fluid.
        2) 4-inch pipe or larger.
            a) Lower Housing: Weld-in saddle seal.
            b) Diaphragm welded to top housing.

c) Diaphragm Material: Type 316L stainless steel.
d) Bottom Housing Material: Type 316L stainless steel.
e) Instrument Connection Size: 1/4-inch or 1/2- inch NPT.
f) Fluid Fill: Acceptable to corresponding process fluid.

2.03 ACCESSORIES

A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

2.05 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be indicated on the Drawings, in the Specifications or both.

END OF SECTION

SECTION 17402
PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for: Valve manifolds and instrument valves.

B. Related Sections: The Contract Documents are a single integrated document, and as such all divisions and sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections to ensure a complete and coordinated Project.

C. Provide all valve manifolds and instrument valves identified in the Contract Documents.

1.02 REFERENCES

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals in accordance with Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data:
    a. Valve type.
    b. Body material.
    c. Size.
    d. Options.
2. Shop Drawings: Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Valve Manifold Manufacturers:

1. One of the following:
   a. Anderson Greenwood.
   b. Hex Valve.
   c. Noshok.
   d. Rosemount.
   e. “Or-equal.”

B. Block and Bleed Valve Manufacturers:

1. One of the following:
   a. Anderson Greenwood.
   b. Hex Valve.
   c. “Or-equal.”

C. Gauge Valve Manufacturers:

1. One of the following:
   a. Anderson Greenwood.
   b. Hex Valve.
   c. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Valve Manifolds:

1. General:
   a. Provide two-valve, three-valve, blowdown type five-valve, or metering type five-valve manifolds as indicated on the Drawings.
   b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
2. Requirements:
   a. Bonnet lock pin to prevent accidental loosening.
   b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
   c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
   d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.

e. Manifold valves shall allow for direct or remote instrument mounting.
f. Shall be able to withstand pressures up to 6,000 pounds per square inch for soft seat valves and 10,000 pounds per square inch for hard seat valves at maximum 200 degrees F.
g. Materials of Construction:
    1) Body Material: Type 316 stainless steel.
    2) O-Ring: Teflon.
h. Two-Valve Manifolds: One isolation valve and one drain/vent and calibration valve.
i. Three-Valve Manifolds:
    1) Two isolation valves and one equalizing valve for differential pressure applications.
    2) Plugged vent connections used for vent/drain or calibration.
j. Blowdown Five-Valve Manifold: Two isolation valves, one equalizing valve, two blowdown valves for differential pressure applications.
k. Metering Five-Valve Manifold: Two isolation valves, two equalizing valves, one vent/drain and calibration valve for differential pressure applications.

B. Block and Bleed Valves:

1. General:
    a. Valve shall provide process isolation and venting/draining capabilities.
    b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
    c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
2. Requirements:
    a. Materials of Construction:
        1) Body Material: Type 316 stainless steel.
        2) O-Ring: Teflon.

C. Gauge Valves:

1. General:
    a. Valve shall provide process isolation from pressure instrument.
    b. Gas leak tested metal to metal hard seat design for hard seat valves.
    c. Gas leak tested soft seat design with replaceable seat for soft seat valves.

2. Requirements:
   a. Materials of Construction:
      1) Body Material: Type 316 stainless steel.
      2) O-Ring: Teflon.

2.03 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument at a facility that is traceable to the National Institute of Testing Standards (NIST).

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weldolets, valves, etc., for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.06 PROTECTION

A. Refer to Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be shown on the Drawings, in the specifications, or both.

END OF SECTION

SECTION 17403
PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure/vacuum switches.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   c. Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
   d. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data: Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before Project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Mechanical Type Pressure Switch:

1. One of the following:
   a. Ashcroft; B Series Type 400.
   b. United Electric Controls; 400 Series.
   c. Dwyer; 1950 Series.
   d. “Or-equal.”

B. Electronic Type Pressure Switch:

1. One of the following:
   a. Ashcroft; N Series.
   b. United Electric; Series One.
   c. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Mechanical Type Pressure Switches:

1. General: Pressure switch shall be diaphragm or diaphragm-sealed piston type.
2. Performance Requirements:
   a. Pressure Range: As specified in data sheets following this section.
   b. Accuracy: Within 1 percent of range.
   c. Repeatability: Within 1 percent of range.

3. Element:
   a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
   b. Overpressure:
      1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
      2) Minimum 400 percent of nominal range without leakage or rupture.
   c. Sensing element shall not require ambient temperature compensation.
   d. Wetted Materials: Stainless steel.
   e. Setpoint:
      1) Dual.
      2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
   f. Fixed deadband.
   g. Switch Elements:
      1) Snap acting.
      2) Single pole-double throw (SPDT) where required.
      3) Two single pole-double throw (SPDT) where required.
      4) Hermetically sealed.
      5) Rated at 5A, 125/250V ac.
      6) Manual reset type.
   h. Enclosure:
      1) Epoxy Coated:
         a) NEMA Type 4X where required.
         b) NEMA Type 7 where required.
   i. Switch Mounting: Process connection: 1/2-inch NPT.
   j. Components: Provide all necessary hardware for pressure switch mounting.

2.03 ACCESSORIES

A. Pulsation Dampeners and Snubbers:

1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
2. Materials: Stainless steel.
3. Mount pulsation dampener or snubber integrally to the pressure switch.
4. Connection: 1/2-inch NPT.

5. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings, and as specified in Section 17401, Pressure/Vacuum Measurement:
   a. Diaphragm and Annular Seals: Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

B. Furnish block and bleed valves as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Furnish gauge valves as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1 hour of Owner training.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULE

A. Example Instrument Data Sheet template included after end of this section.

3.08 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:				**PRESSURE/VACUUM SWITCHES**							
								Spec. No.		**Rev.**	
Contractor:				**No**	**By**	**Date**	**Revision**	17403			
Project:	Digester Phase 6B							**Contract**		**Date**	
Customer:	Clean Water Services										
Plant:	Durham WRRF							**Req.**		**P.O.**	
Location:	Tigard, OR										
BOM No.:								**By**	**Chk**	**App**	
File:											

	1	**Type**			Press: Vacuum: Comp.: Diff.Press: Other	
D	2	**Setting**			Set in Field: Factory Set: Internal: External: Dial:	
E	3	**Dead Band**			**Fixed: Adj.: Min.: Other:**	
V	4	**Mtl :**	**Body**	**Seat** / **Tube**		
I	5	**Element Type**			Diaphragm: Bourdon: Bellows: Other	
C	6	**Material**			Bronze: SS: Alloy St.: Other	
E	7	**Connection**			½ in NPT Bottom: Back:	
	8	**Mounting**			Local: Surface: Flush:	
	9	**Accuracy**				
	10	**Other**				
	11	**Type**			Snap:	
	12	**Quantity**			Single: Dual:	
S	13	**Form**			SPST: SPDT: DPDT: Other	
W	14	**Rating:**	**Amps**	**Volts** / **Hertz**		
I	15	**Other**				
T	16	**Load**			Inductive: Non-Inductive:	
C	17	**Enclosure**			As noted below.	
H	18	**Enclosure Class**				
	19	**Conduit Connection**			MFR STD: Other	
	20	**Other**				
	21	**Manufacturer**				
	22	**Model No.**				

Rev	Tag Number	Adj. Range	SP Process	Signal SP	Op. Temp.	P&ID	Service	Notes

Notes:
1. Refer to Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals, for additional diaphragm seal requirements.
2. Refer to Section 17402, Pressure/Vacuum Measurement: Instrument Valves, for additional instrument valve requirements.

SECTION 17404
PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure/vacuum gauges.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   c. Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
   d. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. American Society of Mechanical Engineers (ASME): B40.100, Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Additional Requirements:

1. Product Data: Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. Manufacturers and Products:

1. One of the following:
   a. Ashcroft:
      1) Maximum Pressure Less Than 10 pounds per Square Inch: Model 1188.
      2) Maximum Pressure Greater Than or Equal to 10 Pounds per Square Inch: Model 1279.
   b. Wika.
   c. Ametek U.S. Gauge.
   d. "Or-equal."

2.02 MANUFACTURED UNITS

A. General: Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance Requirements:

1. Pressure Range: As specified in the Contract Documents.
2. Accuracy:
   a. Grade 2A, as defined by ASME B40.100.
   b. Within 1 percent of span after friction errors are eliminated by tapping or vibration.
   c. Maximum Allowable Friction Inaccuracy: Within 1 percent of span.
3. Element:
   a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
   b. Socket Tips for Bellows and Bourdon Tube:
      1) Materials: Type 316 stainless steel.
   c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
   d. Wetted Materials: Type 316 stainless steel.

4. Dial Gauge:
    a. Dial Size: 4-1/2 inches.
    b. Dial Case Material: Phenolic.
    c. Maximum Pressure Less than 10 Pounds per Square Inch: Aluminum.
    d. Maximum Pressure Greater Than or Equal to 10 Pounds per Square Inch: Aluminum.
    e. Provide safety gauge with safety blow out through the back or top of the unit.
    f. Dial Face: Gasketed shatterproof glass or polycarbonate.
    g. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
    h. Provide gauge locks where possible.
    i. Hermetically sealed.
    j. Connection and Mounting:
        1) Direct mounted and suitable for outdoor installation.
        2) 1/2-inch NPT.
        3) Connection Material: Stainless steel.
    k. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation Dampeners and Snubbers:

1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
3. Materials: Type 316 stainless steel.
4. Mount pulsation dampener or snubber integrally to the pressure gauge.
5. Connection: 1/2-inch NPT.

B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401, Pressure/Vacuum Measurement:

1. Diaphragm and Annular Seals: Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide means for gauge isolation as specified in Section 17402, Pressure/Vacuum Measurement:

1. Instrument Valves:
    a. Mount valve manifold integrally to the gauge.
    b. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050 Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.03 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1/2 hour of Owner training.

3.06 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.07 SCHEDULES

A. Example Instrument Data Sheet template included after end of this section.

B. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

3.08 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:			**PRESSURE GAUGES**						**Spec. No.**		**Rev.**
Contractor:			**No**	**By**	**Date**	**Revision**			17404		
Project:	Digester Phase 6B								**Contract**		**Date**
Customer:	Clean Water Services										
Plant:	Durham WRRF								**Req.**		**P.O.**
Location:	Tigard, OR										
BOM No.:									**By**	**Chk**	**App**
File:											

1	**Type**	Direct Rdg.:		Receiver:		Other:
2	**Mounting**	Surface: Local:				Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum:**	**Phenolic: √**	**Polished SS**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass:			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve:				
11	**Other**	Movement Damping:				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon:		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.:		Bottom:	Other:
17	**Movement**	Dampened:	Standard:		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	**Tag Number**	**Range**	**P&ID**	**Service**	**Notes**

Notes:
Refer to Section 17402, Pressure/Vacuum Measurement: Instrument Valves, for additional instrument valve requirements.

SECTION 17405
PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Pressure transmitters and indicators.

B. Related Sections:

1. Section 01330, Submittal Procedures.
2. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
3. Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
4. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions:

1. Calibrated Range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.
2. Lower Range Value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
3. Upper Range Value (URV): Highest pressure that the pressure transmitter is capable of measuring.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
    a. Installation and mounting requirements.
    b. Location within the process.
    c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before Project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. One of the following:

1. Rosemount; 3051 Series.
2. Yokogawa; EJA Series.
3. Endress + Hauser; Cerabar S Series.
4. “Or-equal.”

2.02 MANUFACTURED UNITS

A. Pressure Transmitters – Direct:

1. General: Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
2. Performance Requirements:
   a. Maximum Ratio of Total Instrument Range to Calibrated Span: 10 to 1.
   b. Accuracy:
      1) Reference Accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.

2) Total Performance Accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.

3. Element:
   a. Diaphragm type transducer integral to pressure transmitter.
   b. Diaphragm Material: Stainless steel or ceramic.
   c. Process Material Compatibility: Verify all material compatibilities with the instrument manufacturer.
   d. Process Connection: As specified in the Instrument Data Sheets.
4. Transmitter:
   a. Power Supply:
      1) 24V dc, two-wire loop powered.
      2) Power Consumption: 3 VA maximum.
   b. Outputs:
      1) Isolated 4 mA dc to 20 mA dc with HART communication protocol.
      2) WLAN or Bluetooth.
   c. Provided with electronic microprocessor.
   d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
   e. Local Display:
      1) 5-digit LCD.
      2) Scaled in engineering units.
   f. Enclosure: NEMA Type 7.
      1) Over Range Protection: To maximum process line pressure.
      2) Conduit: 1/2-inch male NPT.
5. Components:
   a. Transmitter Mounting:
      1) As specified in the Instrument Data Sheets.
      2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 17402, Pressure/Vacuum Measurement: Instrument Valves.

1. Mount valve manifold integrally to the transmitter.
2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.

3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.

B. Provide sun shield for transmitters located in outdoor installations.

1. Face north if possible.
2. Manufacture:
   a. Instrument manufacturer's sun shield.
   b. Intertec DIASHADE SD 67
   c. "Or-equal."

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1 hour of Owner training.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULE

A. Example Instrument Data Sheet template included after end of this section.

3.09 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

Instrumentation Schedule

A/E:			**PRESSURE TRANSMITTERS**								
							Spec. No.		**Rev.**		
Contractor:			**No**	**By**	**Date**	**Revision**	17405				
Project:	Digester Phase 6B						**Contract**		**Date**		
Customer:	Clean Water Services										
Plant:	Durham WRRF						**Req.**		**P.O.**		
Location:	Tigard, OR										
BOM No.:							**By**	**Chk**	**App**		
File:											
GENERAL	**1**	**Instrument Tag No.**									
	2	**Service**									
	3	**P&ID**									
SERVICE	**4**	**Pressure**									
	5	**Process Temperature**									
	6	**Ambient Temperature**									
TRANSMITTER	**7**	**Manufacture**									
	8	**Model No.**									
	9	**Pressure Transmitter Type**									
	10	**Calibrated Span**									
	11	**Accuracy**									
	12	**Adjustable Range**									
	13	**Output Signal**									
	14	**Body Rating**									
BODY	**15**	**Process Flange Type**									
	16	**Drain/Vent**									
	17	**Process Flange**									
	18	**Adapters**									
	19	**Wetted O-Ring**									
	20	**Housing**									
	21	**Bolts**									
	22	**Mounting Brackets**									
	23	**Conduit Entry Size**									
ELEMENT	**24**	**Isolating Diaphragm**									
	25	**Fill Fluid**									
OPTIONS	**26**	**Certification / Approval Type**									
	27	**Meter**									
	28	**Zero Span & Adjustment**									
	29	**Surge Protection**									
	30	**Custom Configuration**									
MANIFOLD	**31**	**Manufacturer**									
	32	**Model Number**									
	33	**Manifold Style**									
	34	**Manifold Type**									

Notes:
Refer to Section 17402, Pressure/Vacuum Measurement: Instrument Valves, for additional instrument valve requirements.

SECTION 17406
PRESSURE/VACUUM MEASUREMENT: DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Differential pressure transmitters and indicators.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
   c. Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
   d. Section 17402, Pressure/Vacuum Measurement: Instrument Valves.
4. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions:

1. Lower Range Value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.

2. Upper Range Value (URV): Highest pressure that the pressure transmitter is capable of measuring.
3. Calibrated Range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than the URV. The calibrated range corresponds to the pressure signal sent from the transmitter.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330, Submittal Procedures and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Product Data: Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Hazardous Classifications
   c. Location within the process.
   d. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT CONDITIONS

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following:

1. Rosemount Series.
2. Endress + Hauser; Deltabar Series.
   a. Direct Differential Pressure: PMD Series.
   b. Differential Pressure Transmitter With two Diaphragm Seals: FMD71.
3. No substitutions allowed.

2.02 MANUFACTURED UNITS

A. Pressure Transmitters - Differential:

1. General:
   a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
   b. Differential pressure transmitters shall be used for differential pressure, flow, or liquid level measurement as indicated on the Drawings.

2. Performance Requirements:
   a. As specified in data sheets or instrument index.
   b. Maximum Ratio of Total Instrument Range to Calibrated Span: 10 to 1.
   c. Accuracy:
      1) Reference Accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
      2) Total Performance Accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
      3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
3. Element:
   a. Diaphragm-type transducer integral or remote to differential pressure transmitter.
   b. Diaphragm material: Stainless steel or ceramic.
   c. Wetted Materials:
      1) Stainless Steel:
         a) Process Material Compatibility: Verify all material compatibilities with the instrument manufacturer.
   d. Diaphragm Fill Fluid: Silicon Oil.
4. Process Connection: As specified in the Instrument List or on the Drawings.
5. Transmitter:
   a. Power Supply:
      1) 24V dc loop powered.
      2) Power Consumption: 3 VA maximum.
   b. Outputs: Isolated 4 mA dc to 20 mA dc with HART communication protocol.
   c. Provided with electronic microprocessor.
   d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
   e. Square root extraction for flow calculation.
   f. Local Display:
      1) External LCD.
      2) Scaled in engineering units.
   g. Enclosure: NEMA Type 4x/6P, explosion proof.
   h. Overrange protection: To maximum process line pressure.
   i. Conduit connection: 1/2 inch male NPT.

6. Components:
   a. Transmitter Mounting:
      1) As specified in the data sheets or instrument index.
      2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide integral diaphragm seals as specified in data sheets or instrument index as indicated on the Drawings and as specified in Section 17401, Pressure/Vacuum Measurement: Diaphragm and Annular Seals.

B. Diaphragm seal and transmitter shall be assembled by manufacturer and shipped as an assembly.

C. Provide flat 4 inch Class 150 flanged diaphragm for tank or vessel level measurement: Flanged diaphragm and transmitter shall be assembled by manufacturer and shipped as an assembly.

D. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Each differential pressure transmitter shall be factory calibrated with 5-point calibration at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning: Furnish 1 hour of Owner training.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be indicated on the Drawings, specified in the Specifications, or both.

3.09 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:			DIFFERENTIAL PRESSURE TRANSMITTERS					Spec. No.		Rev.
Contractor:			No	By	Date	Revision		17406		
Project:	Digester Phase 6B							Contract		Date
Customer:	Clean Water Services									
Plant:	Durham WRRF							Req.		P.O.
Location:	Tigard, OR									
BOM No.:								By	Chk	App
File:										
GENERAL	1	Instrument Tag No.	720LIT7504							
	2	Service	Sludge							
	3	P&ID	720I102							
SERVICE	4	Pressure								
	5	Process Temperature								
	6	Ambient Temperature								
TRANSMITTER	7	Manufacturer								
	8	Model No.								
	9	Pressure Transmitter Type	Differential							
	10	Calibrated Span	0-35 ft							
	11	Accuracy								
	12	Adjustable Range								
	13	Output Signal	4-20 mA							
	14	Body Rating								
BODY	15	Process Flange Type								
	16	Drain/Vent								
	17	Process Flange								
	18	Adapters								
	19	Wetted O-Ring								
	20	Housing								
	21	Bolts								
	22	Mounting Brackets								
	23	Conduit Entry Size								
ELEMENT	24	Isolating Diaphragm								
	25	Fill Fluid								
OPTIONS	26	Certification / Approval Type								
	27	Meter								
	28	Zero Span & Adjustment								
	29	Surge Protection								
	30	Custom Configuration								
MANIFOLD	31	Manufacturer								
	32	Model Number								
	33	Manifold Style								
	34	Manifold Type								

Notes:
Refer to Section 17401 for additional diaphragm seal requirements.
Refer to Section 17402 for additional instrument valve requirements.

SECTION 17602
TEMPERATURE MEASUREMENT: TEMPERATURE GAUGE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Temperature gauges.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.04 SUBMITTALS

A. Furnish submittals as specified in Sections 01330, Submittal Procedures and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location within the process.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before Project Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Bimetallic Type Temperature Gauge:

1. One of the following:
   a. Ashcroft; Type EI.
   b. Weiss Instruments; Series 3BM.
   c. Noshok; 300 Series.
   d. "Or-equal."

B. Liquid Filled Temperature Thermometer:

1. One of the following:
   a. Weksler; Type AS5.
   b. Dwyer; Type IT.
   c. "Or-equal."

C. Gas Actuated Temperature Gauge:

1. One of the following:
   a. Ashcroft; Series 600.
   b. Weiss Instruments; Series G.
   c. Noshok.
   d. "Or-equal."

2.02 MANUFACTURED UNITS

A. Bimetallic Type Temperature Gauges:

1. General: Temperature gauges shall consist of a bimetallic temperature sensor with a dial-type temperature gauge.
2. Performance Requirements:
   a. Temperature Range: As indicated in the Contract Documents.
   b. Accuracy: Within 1 percent of range.
3. Element:
   a. Type: Bimetallic.
   b. Stem Material: Stainless steel.

c. Temperature gauge sensor shall be tamperproof, hermetically sealed, and silicon dampened.
d. Process Connection: 1/2 inch NPT.

4. Dial Gauge:
   a. Dial Size: 3 inches.
   b. Dial Case Material: Stainless steel.
   c. Dial Face: Gasketed shatterproof glass.
   d. Orientation: Straight or angled as required to provide most convenient direct viewing.
   e. Mounting: Direct mounted and suitable for outdoor installation.
   f. External adjustable recalibration screw.

B. Liquid Filled Thermometer:

1. General: Liquid-filled thermometer shall consist of a liquid filled tube.
2. Performance Requirements:
   a. Temperature Range: As indicated in the Contract Documents.
   b. Accuracy: Within 1 percent of range.
3. Element:
   a. Type: Liquid filled in a tube.
   b. Stem Material: Stainless steel.
   c. Easy adjustment permits case and stem to be rotated 360 degrees.
4. Thermometer:
   a. Scale Size: 9 inches.
   b. Scale Material: White aluminum scale with bold black graduations and figures.
   c. Mounting: Direct mounted and suitable for outdoor installation.
5. Thermowell: As specified in this section.

C. Gas actuated Temperature Gauges:

1. General: Temperature gauges shall consist of a gas actuated temperature sensor with a dial-type temperature gauge.
2. Performance Requirements:
   a. Temperature Range: As indicated in the Contract Documents.
   b. Accuracy: Within 1 percent of range.
3. Element:
   a. Type: Gas actuated.
   b. Bulb and capillary material shall be stainless steel.
   c. Temperature gauge sensor shall be tamperproof and hermetically sealed.
   d. Process Connection: 1/2 inch NPT.

4. Dial Gauge:
   a. Dial Size: 4-1/2 inches.
   b. Dial Case Material: Stainless steel.
   c. Dial Face: Gasketed shatterproof glass.
   d. Orientation: Straight or angled as required to provide most convenient direct viewing.
   e. Mounting: As indicated in the Contract Documents.

2.03 ACCESSORIES

A. Thermowell:

1. Unless otherwise noted, provide Thermowell with each temperature gauge.
2. Process Connection: 3/4-inch or as indicated in the Contract Documents.
3. Thermowell Material: Material compatible with the service fluid identified and recommended by the manufacturer for the process condition.
4. Stem style: Tapered.
5. Immersion Depth: Minimum 3 inches or 10 times the diameter of the sensor protection tube or Thermowell, whichever is larger.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum three point calibration or according to manufacturer’s standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer's services to perform start-up and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions: Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 2 hours of Owner training.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents: Instruments may be indicated on the Drawings, specified in the Specifications or both.

3.09 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		**TEMPERATURE GAUGES**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17602			
Project:	Digester Phase 6B					**Contract**		**Date**	
Customer:	Clean Water Services								
Plant:	Durham WRRF					**Req.**		**P.O.**	
Location:	Tigard, OR								
BOM No.:						**By**	**Chk**	**App**	
File:									

1	**Type**	Bimetallic:				Gas Actuated:			
2	**Mounting**	Surface:		Local:		Flush:		Thermowell:	
3	**Stem Material**	Stainless Steel:				Other:			
4	**Thermowell Type**	Straight:		Tapered:		Stepped:			
5	**Thermowell Material**	Stainless Steel:		Other:					
6	**Thermowell Insertion Length**								
7	**Process Connection**	1/2-inch Thread:		3/4-inch Thread:		Flange:		Weld Mount:	
8	**Dial**	Diameter:				Color:			
9	**Case**	Polypropylene:	**Aluminum:**		**Phenolic.:**		**Polished SS**		**Other:**
10	**Lens**	Polycarbonate:		Glass:			Shatterproof Glass:		
11	**Accuracy**								
12	**Manufacturer**								
13	**Model No.**								
14	**Other**								
15	**Other**								

Rev	Tag Number	Range	P&ID	Service	Notes

Notes:

SECTION 17604
TEMPERATURE MEASUREMENT: RTD

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: RTD temperature instruments.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. Section 01330, Submittal Procedures.

B. Section 01756, Testing and Facility Startup.

C. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions:

1. RTD: Resistance temperature detector.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330 Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: Fluids, pressures, temperatures, flows, and materials.
2. Physical Conditions:
    a. Installation and mounting requirements.
    b. Location within the process.
    c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before Project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PRODUCTS

A. One of the following:

1. Endress + Hauser; iTemp TMT142B Transmitter (TH13 build).
2. Rosemount; Model 3144P transmitter with Series 214C sensor.
3. Yokogawa; YTA610 Series Transmitter.
4. “Or-equal.”

2.02 MANUFACTURED UNITS

A. RTD’s:

1. General: Temperature measuring instrument shall include an RTD temperature element, transmitter, and thermowell.
2. Performance Requirements:
   a. Accuracy: Within 0.25 percent of calibrated span.
   b. Repeatability: 0.25 percent of full scale.
   c. Sensor Lead Wire Compensation: Maximum zero shift of 0.2 percent of the temperature range.
3. Element:
   a. 100-Ohm platinum thin film resistance temperature detector (RTD).
   b. Three-wire.
   c. Hermetically sealed, and enclosed in Type 316 stainless steel outer sheath.
   d. Single element temperature sensor shall be spring-loaded.
4. Transmitter:
   a. Microprocessor based.
   b. Compatible with three-wire and four-wire RTD inputs:
   c. Local Display:
      1) 5 digit LCD.
      2) Scaled in engineering units.

d. Power Supply:
   1) 24V dc, loop powered.
   2) Power Consumption: 15 VA maximum.
e. Outputs:
   1) Isolated 4 milliamperes to 20 milliamperes dc with HART communication protocol.
   2) WLan or Bluetooth
f. Transmitter Enclosure: NEMA Type 4X.
g. Connection to Thermowell: 1/2-inch NPT.
h. Transmitter Mounting:
   1) As specified on the Instrument Data Sheets or Instrument Index.
   2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Thermowell:

1. Unless otherwise noted, provide a thermowell with each RTD.
2. Process Connection: 3/4-inch NPT.
3. Thermowell Material: Type 316L stainless steel.
4. Stem Style: Tapered.
5. Include union as necessary to orient transmitter screen to be most accessible.
6. Immersion Depth:
   a. Minimum 3 inches or 10 times the diameter of the thermowell, whichever is larger.
   b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.
   c. As identified on instrument data sheet.
   d. Provide extension when mounted to insulated piping.

B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation.

B. Factory calibrate each instrument with a minimum three-point calibration or according to Manufacturer’s standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

C. Apply thermally conductive silicone grease to the sensor tip before insertion in thermowell.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:

1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

C. Furnish 1 hour of Owner training.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULES

A. Example Instrument Data Sheet template included after end of this section.

B. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

3.09 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Example Instrument Data Sheet.

END OF SECTION

A/E:		**TEMPERATURE TRANSMITTERS - RTD**							
						Spec. No.		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**	17604			
Project:	Digester Phase 6B					**Contract**		**Date**	
Customer:	Clean Water Services								
Plant:	Durham WRRF					**Req.**		**P.O.**	
Location:	Tigard, OR								
BOM No.:						**By**	**Chk**	**App**	
File:									

GENERAL	**1**	**Instrument Tag No.**	
	2	**Service**	
	3	**P&ID**	
SERVICE	**4**	**Process Temperature**	
	5	**Ambient Temperature**	
TRANSMITTER	**6**	**Manufacturer**	
	7	**Model No.**	
	8	**Display**	
	9	**Calibrated Span**	
	10	**Adjustable Range**	
	11	**Accuracy**	
	12	**Output Signal**	
	13	**Body Rating**	
TEMPERATURE ELEMENT	**14**	**Manufacturer**	
	15	**Model No.**	
	16	**Type**	
	17	**Temperature Range**	
	18	**Mounting**	
	19	**Connection**	2-Wire: 3-Wire:X 4-Wire:
	20	**Leads**	Standard: X Potted: Hermetically Sealed:
	21	**Sheath Material**	Stainless Steel
	22	**Element Length**	
THERMOWELL	**23**	**Type**	Straight: Tapered: X Stepped:
	24	**Material**	
	25	**Insertion Length**	
	26	**Process Connection**	1/2-inch Thread: X 3/4-inch Thread: Flange: Weld Mount:
OPTIONS	**27**		
	28		
	29		
	30		
	31		

Notes:

SECTION 17605
TEMPERATURE MEASUREMENT: WALL MOUNT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: RTD temperature instruments.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions:

1. RTD: Resistance temperature detector.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330, Submittal Procedures and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:

1. Process Conditions: temperatures, materials etc.
2. Physical Conditions:
   a. Installation and mounting requirements.
   b. Location.
   c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.08 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 MAINTENANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Furnish all parts, materials, software, communication cable, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following “or-equal”:

1. Pyromation 2215 Series.
2. Omega, EWS Series.
3. Greystone, TE500A Series.

2.02 MANUFACTURED UNITS

A. RTD’s:

1. General:
   a. Temperature measuring instrument shall include an RTD temperature element.
   b. Performance requirements:
   c. Accuracy: Minimum plus or minus 1 degree C.
2. Element: 100-Ohm platinum thin film resistance temperature detector (RTD).

B. Transmitter:

1. Loop powered 4 mA to 20 mA.
2. Wall mountable.

2.03 SOURCE QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 INSTALLATION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Coordinate the installation with all trades to ensure all necessary appurtenances are including for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide manufacturer’s services to perform start-up and calibration or verification.

3.04 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions.

3.05 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.06 DEMONSTRATION AND TRAINING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.07 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.08 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:

1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

3.09 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Instrument Data Sheet.

END OF SECTION

A/E:		**TEMPERATURE TRANSMITTERS - RTD**					**Spec. No.**		**Rev.**	
Contractor:		**No**	**By**	**Date**	**Revision**		17605			
Project:	Digester Phase 6B						**Contract**		**Date**	
Customer:	Clean Water Services									
Plant:	Durham WRRF						**Req.**		**P.O.**	
Location:	Tigard, OR									
BOM No.:							**By**	**Chk**	**App**	
File:										

GENERAL	**1**	**Instrument Tag No.**	725TET5001
	2	**Service**	Room Air
	3	**P&ID**	**008-I-012A**
SERVICE	**4**	**Process Temperature**	32-130 Degrees F
	5	**Ambient Temperature**	
TRANSMITTER	**6**	**Manufacturer**	
	7	**Model No.**	
	8	**Display**	
	9	**Calibrated Span**	
	10	**Adjustable Range**	
	11	**Accuracy**	
	12	**Output Signal**	
	13	**Body Rating**	
TEMPERATURE ELEMENT	**14**	**Manufacturer**	
	15	**Model No.**	
	16	**Type**	RTD
	17	**Temperature Range**	
	18	**Mounting**	
	19	**Connection**	2-Wire: X 3-Wire: 4-Wire:
	20	**Leads**	Standard: X Potted: Hermetically Sealed:
	21	**Sheath Material**	
	22	**Element Length**	
OPTIONS	**23**		
	24		
	25		
	26		

Notes:

SECTION 17710
CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. General:

1. Panel 725LCP9601 is District supplied. Contractor to install and wire.
2. District to assign IO during Loop Drawing submittal review.

B. Section Includes:

1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this Contract, including but not limited to:
   a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low-voltage power distribution, terminal junction boxes, and marshalling panels.
   b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs), package control panels (PCPs), and chemical feed panels.
   c. Control components.
   d. Control panel installation.

C. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor’s Work.
3. The following sections are related to the Work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01330, Submittal Procedures.
   b. Section 01612, Anchorage and Bracing.
   c. Section 16050, Common Work Results for Electrical.
   d. Section 16075, Electrical Identification.
   e. Section 16222, Low-Voltage Motors Up to 50 Horsepower.
   f. Section 16422, Motor Starters.

g. Section 16444, Low-Voltage Motor Control.
h. Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

D. Provide all instruments identified in Contract Documents.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
2. Institute of Electrical and Electronics Engineers (IEEE): C62.41.1 – Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
3. UL:
   a. 508C, Standard for Industrial Control Equipment.
   b. 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
   c. 1283, Standard for Electromagnetic Interference Filters.
   d. 1449, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Specific Definitions: The term “panel” in this section is interchangeable with the term “enclosure.”

1.04 SYSTEM DESCRIPTION

A. Panel Dimensions:

1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s noncertified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
   a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.

b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
c. Maximum Panel Depth: 30 inches, unless otherwise indicated.

B. Structural Design: Completed and installed panel work shall safely withstand seismic requirements at the Project Site as specified in Section 16050, Common Work Results for Electrical. Enclosures, and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

A. Provide submittals as specified in Section 01330, Submittal Procedures, and Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide a control panel hardware submittal, for each control panel and enclosure being provided on this Project, including but not limited to:

1. Product Data:
   a. Enclosure construction details and NEMA type.
   b. Manufacturer’s literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
2. Shop Drawings:
   a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
      1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
   b. Complete nameplate engraving schedule.
   c. Structural details of fabricated panels.
3. Calculations:
   a. Provide installation details based on calculated shear and tension forces:
      1) Calculations shall be signed and sealed by a professional engineer licensed in the state where the cabinets and panels will be installed.
   b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
      1) Weight including panel internal components.
      2) Seismic forces and overturning moments.
      3) Shear and tension forces in connections.

c. Cooling calculations, to include but not limited to:
   1) Highest expected ambient temperature for the enclosure's location.
   2) Internal heat load.
   3) Exposure to direct sunlight.
   4) Dimensions of the enclosure in inches.
   5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

4. Bill of material, including quantity, description, manufacturer, part number, serial number, vendor name with phone, and spare part list with unit price. Bills of material shall include all items within enclosure.
   a. Provide the Bill of material electronically in Microsoft Excel format.

C. Seismic Design:

1. Seismic Panel Construction:
   a. Seismic Anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612, Anchorage and Bracing. Stamped by a professional engineer registered in the state of Oregon.
   b. For floor mounted free-standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612, Anchorage and Bracing. Calculations shall be signed and sealed by a professional engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:

1. Provide all panel components with UL 508 listing.
2. All control panels shall be constructed by a UL 508A certified panel shop.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Project environmental conditions as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

1.09 WARRANTY

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one manufacturer.

2.02 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.

B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:

1. Enclosures shall have the following properties:
   a. NEMA Type 4: Steel with gasketed door, rain tight.
   b. NEMA Type 4X: Type 316 stainless steel.

B. Bolting Material:

1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
2. Carriage bolts for attaching end plates.
3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/Enclosures:

1. Manufacturers:
   a. One of the following:
      1) Saginaw.
      2) Pentair Hoffman.
      3) “Or-equal.”
2. Panel Assembly:
   a. General guidelines for panel fabrication include:
      1) Continuous welds ground smooth.
      2) Exposed surfaces free of burrs and sharp edges.
      3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
   b. Construct enclosure and mounting panel using stretcher level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
82 or more	10	10

1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.

c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

e. Door Construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
   3) Heavy gauge piano type continuous stainless steel hinges.
   4) For NEMA Type 12, Type 4 and Type 4X, provide oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

f. Latches:
   1) For panels each door provided with a three-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely, forming a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.
   2) Include an oil-tight key-locking, three-point latching mechanism on each door:
      a) Provide two keys per panel.
      b) All locks keyed alike.
   3) For large type NEMA Type 4 and NEMA Type 4X cabinets, not available with three-point latching hardware, provide multiple clips and padlock hasps.
   4) Provide quick release latches for all NEMA Type 4 and Type 4X enclosures.

g. Panel Cut-outs:
1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
3) Reinforce around cut-outs with steel angles or flat bars for the following:
a) Large panel cutouts; for example, openings for local operator interfaces.
b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
a. Minimum 14-gauge, Type 316 stainless steel.
b. Captive stainless steel cover screws threaded into sealed wells.
c. Inside Finish: White polyester powder coating.
d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
e. NEMA Type 4X powder coated stainless steel enclosures are not an acceptable substitute for stainless steel.
4. Outdoor Panels:
a. Supplementary requirements for panels located outdoors are as follows:
1) All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
2) Door Hardware: stainless steel.
3) Provide rain canopy and sun shield.
4) Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of Components:

1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the Engineer.
4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent Protection:

1. Main Overcurrent Device:
   a. Where the electrical power supply voltage to the control panel is more than 120V ac, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120V ac circuits:
      1) Door-mounted disconnect handles are not acceptable.
      2) Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be OPENED unless the power is disconnected, and the disconnect switch cannot be closed until all doors are CLOSED.
      3) Provide means to defeat the interlock.
      4) Lockable in the OFF position.
   b. Control Panels Supplied with 120V ac:
      1) Provide an internal breaker with the line side terminals covered by a barrier.
      2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
2. Provide circuit breakers as specified in Section 16444, Low-Voltage Motor Control Centers.
3. Selection and Ratings of Protective Devices:
   a. Interrupting Ratings: Not less than the system maximum available fault current at the point of application.
   b. Voltage Rating: Not less than the voltage of the application.
   c. Select current rating and trip characteristics to be suitable for:
      1) Maximum normal operating current.
      2) Inrush characteristics.
      3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
4. Provide a separate protective device for each powered electrical device:
   a. An individual circuit breaker for each 120V ac instrument installed within its respective control panel and clearly identified for function.
   b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
      1) Size external fuse to open before any I/O card mounted fuses.
   c. An individual 1-ampere fuse for each discrete input loop.
   d. An individual 1/2-ampere fuse for each 4 mA to 20 mA analog loop powered from the control panel.

e. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.

5. Fuses for 4 mA to 20 mA Signals:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. Provide fuses rated for the voltage and available short circuit current at which they are applied.
   c. Manufacturers:
      1) One of the following:
         a) Ferraz Shawmut.
         b) Littelfuse.
         c) Bussmann.
         d) "Or-equal."
6. Fuse Holders:
   a. Modular Type:
      1) DIN rail mounting on 35-millimeters rail.
      2) Touch Safe Design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown fuse indicator.
   b. Provide Nameplate Identifying Each Fuse: As specified in Section 16075, Electrical Identification.
   c. Manufacturers and Product:
      1) One of the following:
         a) Phoenix Contact.
         b) Allen-Bradley; 1492-FB Series B.
         c) "Or-equal."
7. Control Circuit Breakers:
   a. DIN rail mounting on 35-millimeters rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated 250V ac.
   d. Interrupting Rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current Ratings: As indicated on the Drawings or as required for the application.
   f. Provide nameplate identifying each circuit breaker: As specified in Section 16075, Electrical Identification.
   g. Manufacturers:
      1) One of the following:
         a) Phoenix Contact.
         b) ABB.
         c) Allen-Bradley Series.

d) Square D.
e) “Or-equal.”

D. Conductors and Cables:

1. Power and Control Wiring:
   a. Materials: Stranded, soft annealed copper.
   b. Insulation: 600V type MTW.
   c. Minimum Sizes:
      1) Primary Power Distribution: 12 AWG.
      2) Secondary Power Distribution: 14 AWG.
      3) Control: 16 AWG.
   d. Color:
      1) BLACK, RED – 120/240V ac Single-Phase (line and load) conductors.
      2) RED – 120V ac conductors within control panel (Discrete Input and Output).
      3) ORANGE – 120V control conductors internal to the control panel.
      4) YELLOW – 120V conductors external to the control panel.
      5) GREEN – Ground wire.
      6) WHITE – 120V Neutral conductors.
      7) A-Brown, B-Orange, C-Yellow – 277/480V three-phase conductors.
      8) GRAY – 277 Neutral conductors.
      9) BLUE – DC positive conductors.
      10) WHITE with BLUE stripe - DC negative (grounded) conductors.
2. Signal Cables, Twisted Shielded:
   a. Materials: Stranded, soft annealed copper.
   b. Insulation: 600V, PVC outer jacket.
   c. Minimum Size: 18 AWG paired/triad.
   d. Overall aluminum shield (tape).
   e. 20 AWG seven-strand tinned copper drain wire.
   f. Color:
      1) Two Conductor:
         a) Positive (+): WHITE.
         b) Negative (-): BLACK.
      2) Three Conductor:
         a) Positive (+): WHITE.
         b) Negative (-): BLACK.
         c) Signal: RED.
   g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor Identification:

1. Identify each conductors and cables with unique wire numbers as specified in Section 16075, Electrical Identification.
2. Readily identified without twisting the conductor.

F. General Wiring Requirements:

1. Wiring Methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for all control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
7. Provide nonmetallic ducts for routing and organization of conductors and cables:
    a. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
    b. Provide separate ducts for signal and low voltage wiring from power and 120V ac control wiring:
        1) 120V ac: Grey colored ducts.
        2) 24V dc: White colored ducts.
8. Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:
    a. Screw-on cable tie mounts.
    b. Hammer-on cable tie mounting clips.
    c. Fingers of the nonmetallic duct.
9. The free ends of cable ties shall be cut flush after final adjustment and fastening.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    a. Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

13. The control panel shall be the source of power for all 120V ac devices interconnected with the control panel including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

2.05 COMPONENTS

A. Thermal Management:

1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.
2. Heating:
    a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:
        1) The panel is not supplied with 120V ac power.
        2) There are no electronics or moisture-sensitive devices in the enclosure.
        3) The panel is smaller than 38 inches high.
3. Heat Exchanger:
    a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
    b. Filterless design to facilitate easy cleaning of the core.
    c. Mounting: Indicated on the Drawings.
4. Enclosure temperature sensor as indicated on the Drawings:
5. Enclosure Temperature Switch:
    a. Provide wall mount bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Sensor and electronic enclosure.
    c. Accuracy: Within 2 degrees F.
    d. Manufacturer and Product:
        1) The following:
            a) Hoffman; ATEMNC.
            b) “Or-equal.”
6. Fan Ventilation:
    a. Temperature Control Switch and Alarm:
        1) Power: 120V ac.
        2) Bimetallic temperature senor.
        3) Adjustable setpoint range 30 degrees F to 140 degrees F.

4) Manufacturer and Product:
a) Hoffman; ATEM series.
b) "Or-equal."

B. Panel meters.

C. Pilot Devices:

1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size: 30.5 millimeters.
c. Heavy duty.
d. Pushbuttons:
1) Contacts Rated: NEMA Type A600.
2) Furnish one spare normally OPEN and normally CLOSED contact with each switch.
e. Selector Switches:
1) Contacts Rated:
a) NEMA Type A600.
b) Knob type.
2) Furnish one spare normally OPEN contact and normally closed contact with each switch.
3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot Lights:
1) Type: LED.
2) Push to test.
3) Lamp Color:
a) ON/RUNNING/START: Red.
b) OFF/STOP: Green.
c) POWER: White.
d) ALARM: Amber.
e) STATUS or NORMAL Condition: White.
f) OPENED: Red.
g) CLOSED: Green.
h) FAILURE: Amber.
2. Indoor and Outdoor Areas:
a. NEMA Type 4/13.
b. Manufacturers and Products:
1) One of the following:
a) Allen-Bradley; Type 800T.
b) Square D; Class 9001 Type K.
c) General Electric; Type CR104P.

d) IDEC; TWTD.
e) "Or-equal."

3. Corrosive Areas:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
   d. Manufacturers and Products:
      1) One of the following:
         a) Cutler Hammer; Type E34.
         b) Square D; Class 9001 Type SK.
         c) Allen-Bradley; Type 800H.
         d) IDEC; TWTD.
         e) "Or-equal."
4. Hazardous (Classified) Areas/Class I Division 2:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc:
      1) All contacts contained within a hermetically sealed chamber:
         a) Pushbuttons.
         b) Selector switches.
         c) Push-to-test contacts on pilot lights.
      2) UL listed and labeled for Class I Division 2 areas.
   d. Manufacturers and Products:
      1) One of the following:
         a) Cutler Hammer; Type E34.
         b) ABB/Entrelec; M4/8 Series.
         c) "Or-equal."

D. Potentiometer and Slidewire Transmitters:

1. Provide a dc output in proportion to a potentiometer input.
2. Potentiometer Input:
   a. 100 ohms to 100 K ohms.
   b. Impedance Greater or equal to 1 M ohms.
   c. Zero Turn-up: 80 percent of full scale input.
   d. Span Turn-down: 80 percent of full scale input.
3. Field Configurable Output:
   a. Voltage and Current: All conventional current loops and voltage control signals.
4. Accuracy including linearity and hysteresis within 0.1 percent max at 25 degrees C.

5. Operating Temperature: 32 degrees F to 131 degrees F.
6. Supply Power: 9V dc to 30V dc.
7. Manufacturer:
    a. The following:
        1) Phoenix Contact.
        2) “Or-equal.”

E. Signal Isolators and Converters:

1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum Isolation Level: 1.5 kilovolts ac/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient Temperature Range: Minus 4 degrees F to plus 149 degrees F.
2. Manufacturers and Products:
    a. One of the following:
        1) Phoenix Contact; MCR Series.
        2) Acromag; 1500, 600T, 800T, Flat Pack or ACR Series.
        3) Action Instruments; Q500 Series or Ultra SlimPakII.
        4) AGM Electronics; Model TA-4000.
        5) “Or-equal.”

F. Relays:

1. General:
    a. For all types of 120V ac relays, provide surge protection across the coil of each relay.
    b. For all types of 24V dc relays, provide a free-wheeling diode across the coil of each relay.
2. General Purpose:
    a. Magnetic control relays.
    b. NEMA Type A300 Rated:
        1) 300 volts.
        2) 8 amps continuous (minimum).
        3) 7,200 volt-amperes make.
        4) 720 volt-amperes break.
    c. Plug-in type.
    d. LED indication for energization status.
    e. Coil Voltages: As required for the application.
    f. Minimum Poles: DPDT.

g. Touch Safe Design: All connection terminals to be protected against accidental touch.
h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (interposing) relays when the following occurs:
    1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
    2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35-millimeters rail.
m. Ice cube type relays with retainer clips to secure relay in socket.
n. Integrated label holder for device labeling.
o. Manufacturer and Products:
    1) One of the following:
        a) Potter and Brumfield; Type KUMP.
        b) Eaton; D5PF.
        c) IDEC; RR series.
        d) Allen-Bradley; Type 700 H Series.
        e) Square D; Type K.
        f) “Or-equal.”

3. Latching:
    a. Magnetic latching control relays.
    b. NEMA Type B300 Rated:
        1) 300 volts.
        2) 10 amps continuous.
        3) 3,600-volt-amperes make.
        4) 320 volt-amperes break.
    c. Plug-in type.
    d. DIN rail mounting on 35-millimeters rail.
    e. Coil Voltage: As required for the application.
    f. Minimum Poles: 2PDT; as required for the application plus 1 spare pole.
    g. Touch Safe Design: All connection terminals to be protected against accidental touch.
    h. Clear cover for visual inspection.
    i. Provide retainer clip to secure relay in socket.
    j. Manufacturers and Products:
        1) One of the following:
            a) Square D; Type 8501 Type K.

b) IDEC; TWTD.
c) "Or-equal."

k. Provide relays with push to test and manual override lever.

4. Time Delay:
   a. Provide time delay relays to control contact transition time.
   b. Contact Rating:
      1) 240 volts.
      2) 10 amps continuous.
      3) 3,600 volt-amperes make.
      4) 360 volt-amperes break.
   c. Coil Voltage: As required for the application.
   d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off delay:
      1) For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.
   e. Minimum Poles: 2PDT.
   f. Units include adjustable dial with graduated scale covering the time range in each case.
   g. Minimum Timing Range: 0.1 second to 10 minutes, or as required for the application.
   h. Manufacturer and Products:
      1) One of the following:
         a) IDEC; RTE Series.
         b) Agastat; Type Series 7000 Series (pneumatic).
         c) Allen-Bradley; Type 700HR Series.
         d) "Or-equal."

G. Terminal Blocks:

1. Din rail mounting on 35-mm rail.
2. Suitable for specified AWG wire.
3. Rated for 15 amperes at 600 volts.
4. Screw terminal type.
5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
6. Finger safe protection for all terminals for conductors.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from minus 40 degrees F to 221 degrees F.
8. Terminals: Plainly identified to correspond with markings on the diagrams: Permanent machine printed terminal identification.

9. Disconnect type field signal conductor terminals with socket/screw for testing.
10. Identify terminals suitable for use with more than one conductor.
11. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
12. Provide minimum 25 percent spare terminals.
13. Manufacturers and Products:
    a. One of the following:
        1) Phoenix Contact; UK5 Series.
        2) ABB/Entrelec; M4/8 Series.
        3) "Or-equal."
14. Wire Duct:
    a. Provide flame retardant plastic wiring duct, slotted with dust cover.
    b. Type:
        1) Wide slot.
        2) Narrow slot.
        3) Round hole.
    c. Manufacturer:
        1) The following:
            a) Panduit.
            b) "Or-equal."

H. Surge Protection Devices:

1. Control Panel Power:
    a. 120-volt Control Power Source:
        1) Non-UPS Powered:
            a) Provide surge protection device (SPD) for panel power entrances:
                (1) Nominal 120V ac with a nominal clamping voltage of 200 volts.
                (2) Non-faulting and noninterrupting design.
                (3) A response time of not more than 5 nanoseconds.
            b) Control panel power system level protection, non-UPS powered:
                (1) Design to withstand a maximum 10 kA test current of a 8/20 µs waveform according to IEEE C62.41.1Category C Area.

(2) For panels receiving power at 120V ac, provide surge protection at secondary of main circuit breaker.
(3) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
(4) DIN rail mounting.
(5) Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
(a) Gas-tight connections.
(b) The Terminal Block: Fabricated of nonferrous, non-corrosive materials.
(6) Visual status indication of MOV status on the input and output circuits.
(7) Dry contact rated for at least 250V ac, 1 amp for remote status indication.
(8) Meeting the following requirements:
(a) Response Time: Less than or equal to 100 ns.
(b) Attenuation: Greater than or equal to minus 40 dB at 100 kilovolt-hertz as determined by a standard 50 ohms insertion test.
(c) Safety Approvals:
(d) UL 1283 (EMI/RFI Filter).
(e) UL 1449 2nd Edition.
(9) Manufacturers and Product:
(a) One of the following:
(b) Phoenix Contact; Type SFP TVSS/Filter.
(c) Sola.
(d) “Or-equal.”

b. 120-volt Control Power Source: UPS powered.
1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
2) Location:
a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
(1) Surge protection is not required for 120V ac circuits that are only used for panel lights and receptacles.

b) For panels receiving power at 480V ac, provide surge protection on the 120V ac control power transformer secondary.

3) MCOV: 150V ac.
4) Surge Capability (8/20 microsecond wave): 10 kA.
5) Peak Let-through: 620V L-N, 850V L-G.
6) Manufacturers and Products:
a) One of the following:
(1) Phoenix Contact; Plugtrab PT Series.
(2) MTL Surge Technologies; MA15 Series.
(3) "Or-equal."

2. Instrument, Data and Signal Line Protectors (Traditional I/O) – Panel Mounted:
a. Surge Protection Minimum Requirements: Withstand a 10 kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. DIN rail mounting on 35 millimeters rail (except field mounted SPDs).
c. SPDs Consisting of Two Parts:
1) A base terminal block.
2) A Plug Protection Module:
a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
b) Base and plug coded to accept only the correct voltage plug.
d. SPD Manufacturers and Products:
1) One of the following:
a) Phoenix Contact; Plugtrab Series.
b) Bournes; Series 1800.
c) "Or-equal."

3. Instrument, Data and Signal Line Protectors (Traditional I/O) – Field Mounted:
a. Surge Protection Minimum Requirements: Withstand a minimum 10 kA test current of a 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
b. Manufacturers and Products:
1) One of the following:
a) Plugtrab; PT Series.
b) MTL; TP48 Series.
c) "Or-equal."

I. Power Supplies:

1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
2. Convert 120V ac to 24V dc or other dc voltages required or as required for the application.
3. Provide backup 24V dc power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
    a. Provide automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
5. Sized to provide 40 percent excess rated capacity.
6. UL 508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of one set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output Regulation:
    a. Within 0.05 percent for a 10 percent line change or a 50 percent load change: With remote voltage sensing.
10. Operating Temperature Range: 32 degrees F to 122 degrees F.
11. Touch Safe Design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35-millimeters rail.
13. Provide self-protecting power supplies with a means of limiting dc current in case of short circuit.
14. Manufacturers and Products:
    a. One of the following:
        1) Phoenix Contact; Quint Series.
        2) IDEC; PS5R Series.
        3) Sola.
        4) Allen-Bradley; Series 1606.
        5) “Or-equal.”

J. Intrinsic Safety Barriers:

1. Transformer Isolated Barrier:
    a. Containing a Transformer to Provide Complete:
        1) Isolation between the safe and hazardous areas for loop powered devices.
        2) Three-way isolation between the safe area, hazardous area and power supply powered devices.

b. Resistor for current limitation.
c. Fuses for short circuit protection.
d. Provide barriers with pluggable connectors that are coded for easy replacement.
e. Transmission error shall be less than or equal to 0.1 percent of full scale.
f. DIN rail mounted on 35-millimeters DIN rail.
g. Approvals:
    1) FM.
    2) UL 913.

2. Types:
    a. Switch Isolators:
        1) Designed and approved for use with discrete inputs.
        2) Supply Power: 120V ac.
        3) Output to track input.
        4) LED in the cover to indicate the status of the input.
        5) Selector switch to change the logic of the input.
        6) Input: Dry contact.
        7) Output: SPDT relay.
    b. Transmitter and converters for use with 4 mA to 20 mA signals without Hart® communications capability:
        1) Designed and approved for use with 4 mA to 20 mA analog signals.
        2) Designed for powering two- and/or three-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
        3) Supply Voltage: 20V dc to 30V dc.
    c. Transmitter and converters for use with 4 mA to 20 mA signals with Hart® communications capability:
        1) Designed and approved for use with 4 mA to 20 mA analog signals.
        2) Designed for powering two- and/or three-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
        3) Transfer digital signals from the hazardous area to the safe area.
        4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
        5) Supply Voltage: 20V dc to 30V dc.
3. Manufacturers and Product:
    a. One of the following:
        1) Phoenix Contact; ME Series.

2) Pepperl+Fuchs.
3) “Or-equal.”

K. Starters:

1. Magnetic Motor Starters: As specified in Section 16422, Motor Starters.

L. Variable Frequency Drives: As specified in Section 16262, Variable Frequency Drives, 0.5 hp to 50 hp.

M. Limit Switches:

1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating Temperature Range: Minus 18 degrees C to plus 110 degrees C (0 degree F to 230 degrees F).
9. Manufacturers and Products:
   a. One of the following:
      1) Allen-Bradley; 802.
      2) Honeywell; HDLS.
      3) Omron; D4.
      4) Eaton; E47, E49, E50.
      5) ABB.
      6) “Or-equal.”

N. Current Switches:

1. Operate from 120V ac supply voltage.
2. One normally open and normally closed contacts.
3. Adjustable current setting.
4. Manufacturer and Product: Zelio; RM35.

O. Isolation Transformer:

1. An isolation transformer shall be provided for all control panels as indicated on the Drawings.
   a. Minimum Size: 3 kVA.
   b. Shielded.
   c. Low noise.

d. Mounted outside of the control enclosure when indicated on the Drawings.

2. The panel lights, convenience receptacle and environmental controls shall not be powered from the isolation transformer.

3. Manufacturers and Product:
   a. One of the following:
      1) Acme; T-3-53043-S.
      2) General Electric.
      3) Jefferson.
      4) “Or-equal.”

P. Ethernet Switches:

1. Unmanaged Ethernet Switches:
   a. Manufacturers and Products:
      1) One of the following:
         a) Allen-Bradley; 1783-US5T.
         b) Phoenix Contact; 2891673.
         c) “Or-equal.”
   b. Properties:
      1) Power Supply:
         a) Provide redundant power supplies.
         b) 24V dc power supply.
         c) Alarm output indicating loss of power supply.
      2) Performance:
         a) 10/100/1000, Full/half-Duplex.
         b) MDI/MDI-X Auto-sensing.
      3) Environment:
         a) Operating Temperature Range: Minus 13 degrees F to 167 degrees F.
         b) Humidity: 15 percent to 95 percent, noncondensing.
      4) Connector Type:
         a) Copper: RJ-45.
      5) Mounting: Din Rail.

2.06 ACCESSORIES

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with one copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of

control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Provide nameplate to each panel as indicated on the Drawings:

1. Provide as specified in Section 16075, Electrical Identification, on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
    a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Power Source or Circuit ID.
    d. Short-circuit current rating of the panel based on one of the following:
        1) Short-circuit current rating of a listed and labeled assembly.
        2) Short-circuit current rating established utilizing an approved method.
3. Provide enclosures with a flange mounted disconnect that is interlocked with the doors.

F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:

1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Lighting:

1. Provide one luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. Provide On-Off door-activated switches where indicated on the Drawings.
    c. Provide LED Lamp for Indoor Enclosures: Provide additional fixtures for every 36 inches of width.

H. Receptacles:

1. Provide one duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 125-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

I. Grounding:

1. Provide the following:
   a. Grounding strap between enclosure doors and the enclosure.
   b. Equipment grounding conductor terminals.
   c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
   d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND" or the letter "G," or the color green.
3. Signal (24V dc) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment- bonding jumper.
10. Bond together all control panels both remote and local, processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit to provide a common ground reference.

J. Provide sunshades for outdoor installations.

2.07 FINISHES

A. Finishes:

1. Metallic (non-stainless):
   a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
   b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry film thickness, and allowed to dry before applying the finish coat.
   c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
   d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless Steel: Stainless enclosures shall be provided with a number 4 brushed finish - not painted.

B. Colors:

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

2.08 SOURCE QUALITY CONTROL

A. As specified in 17050, Basic Measurement and Control Instrumentation Materials and Methods.

B. Factory calibrate each instrument with a minimum three-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the Project Site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the Project Site.

C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.

D. Provide 3-1/2-inch high concrete housekeeping pads for free-standing enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit: Undercoat floor mounted panels.

F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc., shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the Contractor.

I. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.04 CLEANING

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

3.05 PROTECTION

A. As specified in Section 17050, Basic Measurement and Control Instrumentation Materials and Methods.

END OF SECTION

SECTION 17901
INSTRUMENT LIST

PART 1 GENERAL

1.01 SUMMARY

A. The Instrument list is not a take-off list. Refer to the Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the Instrument Index are defined on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSTRUMENT LIST

A. Columns include the following:

1. Tag: Tag number is a unique number that identifies the instrumentation on the Drawings.
2. Description: Describes the instrument or device.
3. Size: Indicates the size of instrument to apply for flow meters and some others. This field does not apply to all instruments.
4. Output Type: For instrumentation that is monitored by the PLC or other devices the signal will be either 4 mA to20 mA analog signal or dry contact for discrete signals. None indicates that the instrument is not interface to a PLC or other monitoring device.
5. Calibration: Instrumentation calibration is provided in engineering units. For analog signals, gauges, and rotometers a range will be provided. For discrete instruments, a contact open or close above or below a value will be given. The Contractor shall coordinate Owner during construction on all calibration ranges indicated in the schedule.
6. Power Type: “4-Wire” indicates the analog instrument will be provided with a power source. “2-Wire” indicates the instrument will be loop powered from the PLC. “120V ac” indicates the signal will be 120V ac discrete signal. “None” indicates the instrument is mechanically indicated.
7. P&ID Drawing: Indicates which P&ID the instrument is shown.
8. Specification: Provides a reference to the instrumentation specification requirements.
9. Installation Details: Provides a reference to all applicable installation details.

3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Instrument List.

END OF SECTION

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES		SPEC	DETAIL
1	DC1 WASTE GAS BURNER FLOW	740FIT6904, 740FE6904	Flow Element and Transmitter, Thermal Mass Flow	008-I-001	Range: Meter Size: Transmitter: Sun Shield Stanchion: In-Situ Verification: Gas: Hazardous Rating: Flow Element Mount: Retractable System: Enclosure:	0 - 1200 scfm, fit 6 inch pipe. Remote Mount Provide sun shield Facing north if possible Factory Ready Digester Gas Class 1, Division 1 Side Mounted in pipe Retractable System. Teflon seals Provide explosion proof instrumentation that does not require intrinsically safe circuitry to be intrinsically safe.	17305	13217, 17380
2	FOG WASTE FEED PUMP 3 DISCHARGE PRESSURE	715PI6406 715PE6406	Pressure Gauge, Diaphragm Seal	008-I-009A	Range: Pipe Size:	0 - 60 psig 2-inch	17401 17404	17304A, 17305
3	FOG WASTE FEED PUMP 3 DISCHARGE PRESSURE SWITCH	715PSH6406	Pressure Switch	008-I-009A	Setpoint: Seal:	55 psig Part of 715PE6406 assembly	17403	17304C
4	FOG WASTE FEED PUMP 3 SEAL WATER FLOW	715FI6406	Flow, Rotameter	008-I-009A	Range: Meter Size: Liquid: Flow Element Mount: Location:	0.5 - 5 gpm. Non-potable water Vertical - 1/2" Indoors	17316	17220
5	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER SUPPLY TEMPERATURE	725TIT6611S 725TE6611S	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
6	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER RETURN TEMPERATURE	725TIT6611R 725TE6611R	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
7	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE FLOW	725FE6701 725FIT6701	Flow Element and Transmitter, Clamp-on Ultrasonic, Doppler	008-I-010A	Range: Pipe Size: Process Fluid:	0 - 650 gpm, 8 inches Recirculating Sludge Flow	17311	17217, 17388
8	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE INLET TEMPERATURE	725TIT6701A 725TE6701A	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
9	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE OUTLET TEMPERATURE	725TIT6701B 725TE6701B	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 8 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES	SPEC	DETAIL
10	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER SUPPLY TEMPERATURE	725TIT6612S 725TE6612S	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
11	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER RETURN TEMPERATURE	725TIT6612R 725TE6612R	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
12	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE FLOW	725FE6702 725FIT6702	Flow Element and Transmitter, Clamp-on Ultrasonic, Doppler	008-I-010A	Range: Pipe Size: Process Fluid:	0 - 650 gpm, 8 inches Recirculating Sludge Flow	17311	17217, 17388
13	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE	725TIT6702A 725TE6702A	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
14	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE	725TIT6702B 725TE6702B	Temperature Transmitter, Temperature Element, Thermowell	008-I-010A	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 8 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
15	DC2 SLUDGE RECIRCULATION PUMP 6 INLET PRESSURE	725PI6706A 725PE6706A	Pressure Gauge, Diaphragm Seal	008-I-010A	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
16	DC2 SLUDGE RECIRCULATION PUMP 6 DISCHARGE PRESSURE	725PI6706B 725PE6706B	Pressure Gauge, Diaphragm Seal	008-I-010A	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
17	DC2 SLUDGE RECIRCULATION PUMP 6 SEAL WATER FLOW	725FI6706	Flow, Rotameter	008-I-010A	Range: Meter Size: Liquid: Flow Element Mount: Location:	0.5 - 5 gpm. Non-potable water Vertical - 1/2" Indoors	17316	17220
18	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER SUPPLY TEMPERATURE	725TIT6613S 725TE6613S	Temperature Transmitter, Temperature Element, Thermowell	008-I-010B	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
19	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER RETURN TEMPERATURE	725TIT6613R 725TE6613R	Temperature Transmitter, Temperature Element, Thermowell	008-I-010B	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 4 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
20	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE FLOW	725FE6703 725FIT6703	Flow Element and Transmitter, Clamp-on Ultrasonic, Doppler	008-I-010B	Range: Pipe Size: Process Fluid:	0 - 650 gpm, 8 inches Recirculating Sludge Flow	17311	17217, 17388

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES	SPEC	DETAIL
21	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE	725TIT6703A 725TE6703A	Temperature Transmitter, Temperature Element, Thermowell	008-I-010B	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 8 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
22	DC 2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE	725TIT6703B 725TE6703B	Temperature Transmitter, Temperature Element, Thermowell	008-I-010B	Range: Pipe Size: Transmitter: Insertion Length:	40 - 220 deg F 8 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
23	DC2 SLUDGE RECIRCULATION PUMP 3 INLET PRESSURE	725PI6703A 725PE6703A	Pressure Gauge, Diaphragm Seal	008-I-010B	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
24	DC2 SLUDGE RECIRCULATION PUMP 3 DISCHARGE PRESSURE	725PI6703B 725PE6703B	Pressure Gauge, Diaphragm Seal	008-I-010B	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
25	DC2 SLUDGE RECIRCULATION PUMP 3 SEAL WATER FLOW	725FI6703	Flow, Rotameter	008-I-010B	Range: Meter Size: Liquid: Flow Element Mount: Location:	0.5 - 5 gpm. Non-potable water Vertical - 1/2" Indoors	17316	17220
26	DC2 SLUDGE RECIRCULATION PUMP 3 & 4 HIGH SEAL WATER PRESSURE	725PI6711	Pressure Gauge	008-I-010B	Range: Meter Size: Liquid:	0 - 100 psig. Non-potable water	17404	17302
27	DC2 SLUDGE RECIRCULATION PUMP 3 & 4 LOW SEAL WATER PRESSURE	725PI6713	Pressure Gauge	008-I-010B	Range: Meter Size: Liquid:	0 - 50 psig. Non-potable water	17404	17302
28	DC2 SLUDGE RECIRCULATION PUMP 4 INLET PRESSURE	725PI6704A 725PE6704A	Pressure Gauge, Diaphragm Seal	008-I-010B	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
29	DC2 SLUDGE RECIRCULATION PUMP 4 DISCHARGE PRESSURE	725PI6704B 725PE6704B	Pressure Gauge, Diaphragm Seal	008-I-010B	Range: Pipe Size: Flanges:	0 - 30 psig 8 inch 150# SS Flanges.	17401 17404	17304C
30	DC2 SLUDGE RECIRCULATION PUMP 4 SEAL WATER FLOW	725FI6704	Flow, Rotameter	008-I-010B	Range: Meter Size: Liquid: Flow Element Mount: Location:	0.5 - 5 gpm. Non-potable water Vertical - 1/2" Indoors	17316	17220
31	FOG WASTE FEED FLOW	725FE6401 725FIT6401	Flow Element and Transmitter, Clamp-on Ultrasonic, TOF	008-I-010B	Range: Pipe Size: Process Fluid:	0 - 150 gpm, 2 inches Waste Activated Sludge	17310	17217, 17388
32	DC2 PRIMARY HEAT LOOP PUMP 1 PRESSURE	725PI6601	Pressure Gauge	008-I-011	Range: Meter Size: Liquid:	0 - 80 psig. Hot water	17404	15200
33	DC2 PRIMARY HEAT LOOP PUMP INLET PRESSURE	725PIT6601A	Pressure Transmitter	008-I-011	Range: Transmitter:	0 - 80 psig Pipe mount	17402 17405	17302
34	DC2 PRIMARY HEAT LOOP PUMP DISCHARGE PRESSURE	725PIT6601B	Pressure Transmitter	008-I-011	Range: Transmitter:	0 - 80 psig Remote Mount	17402 17405	17304B
35	DC2 PRIMARY HEAT LOOP PUMP 2 PRESSURE	725PI6602	Pressure Gauge	008-I-011	Range: Meter Size: Liquid:	0 - 80 psig. Hot water	17404	15200

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES	SPEC	DETAIL
36	DC 2 BOILER 3 FEED INLET TEMPERATURE	725TI6623 725TE6623	Temperature Indicator, Thermowell	008-I-011A	Type: Range: Pipe Size: Insertion Length:	Bimetallic 30-240 deg F 6 inch Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17602	13361A 13361B
37	DC 2 BOILER 4 FEED INLET TEMPERATURE	725TI6624 725TE6624	Temperature Indicator, Thermowell	008-I-011A	Type: Range: Pipe Size: Insertion Length:	Bimetallic 30-240 deg F 6 inch Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17602	13361A 13361B
38	DC 2 BUILDING HOT WATER SUPPLY TEMPERATURE	725TIT6616 725TE6616	Temperature Transmitter, Temperature Element, Thermowell	008-I-012	Range: Pipe Size: Transmitter: Insertion Length:	50-200 deg F 3 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
39	DC 2 IPS BUILDING HOT WATER SUPPLY TEMPERATURE	725TIT6617 725TE6617A 725TE6617B	Temperature Transmitter, Temperature Element, Thermowell	008-I-012	Range: Pipe Size: Transmitter: Insertion Length:	50-200 deg F 3 inch Remote Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
40	DC2 SLUDGE HEAT EXCHANGER HOT WATER PUMP 3 PRESSURE	725PI6613	Pressure Gauge	008-I-012A	Range: Meter Size: Liquid:	0 - 80 psig. Hot water	17404	15200
41	SECONDARY HEAT LOOP RECIRCULATION PUMP 1 PRESSURE	715PI6601	Pressure Gauge	008-I-013	Range: Meter Size: Liquid:	0 - 80 psig. Hot water	17404	15200
42	SECONDARY HEAT LOOP RECIRCULATION PUMP 2 PRESSURE	715PI6602	Pressure Gauge	008-I-013	Range: Meter Size: Liquid:	0 - 80 psig. Hot water	17404	15200
43	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE	720TIT6601A 720TE6601A	Temperature Transmitter, Temperature Element, Thermowell	008-I-015	Range: Pipe: Transmitter: Insertion Length:	40-220 deg F Flange Connection Remote Insertion length slightly past center of main pipe flow	17604	13361A 13361B 17388A
44	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE	720TIT6601B 720TE6601B	Temperature Transmitter, Temperature Element, Thermowell	008-I-015	Range: Pipe Size: Transmitter: Insertion Length:	40-220 deg F 6 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
45	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE	720TIT6602A 720TE6602A	Temperature Transmitter, Temperature Element, Thermowell	008-I-015	Range: Pipe: Transmitter: Insertion Length:	40-220 deg F Flange Connection Remote Insertion length slightly past center of main pipe flow	17604	13361A 13361B 17388A

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES	SPEC	DETAIL
46	DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE	720TIT6602B 720TE6602B	Temperature Transmitter, Temperature Element, Thermowell	008-I-015	Range: Pipe Size: Transmitter: Insertion Length: 40-220 deg F 6 inch Integral Insertion length 15-times thermowell diameter or just slightly past pipe center if small pipe	17604	13361A 13361B
47	DC2 DIGESTER 3 NPW SCUM BOX FLOW	725FI6911	Flow, Rotameter	008-I-016	Range: Meter Size: Liquid: Flow Element Mount: Location: 1 - 10 gpm. Non-potable water Vertical - 1" Outdoor	17316	17220
48	DC2 DIGESTER 3 NPW FOAM SEPARATOR FLOW	725FI6912	Flow, Rotameter	008-I-016	Range: Meter Size: Liquid: Flow Element Mount: Location: 1 - 10 gpm. Non-potable water Vertical - 1" Outdoor	17316	17220
49	DC2 DIGESTER 3 NPW MIXER SEAL WATER FLOW	725FI6913	Flow, Rotameter	008-I-016	Range: Meter Size: Liquid: Flow Element Mount: Location: 0.025 - 0.25 gpm. Non-potable water Vertical - 1/4" Outdoor	17316	17220
50	DC2 DIGESTER 3 DIGESTER GAS PRESSURE	725PIT6903 725PE6903	Pressure Transmitter, Diaphragm Seal	008-I-016	Range: Sun Shield: Orientation: Hazardous Rating: Enclosure: 0 - 25 inches water column Provide sun shield. Face north if possible but allow for access. Class 1, Division 1 Provide explosion proof instrumentation that does not require intrinsically safe circuitry to be intrinsically safe.	17402 17405	17304A, 17305
51	DC2 DIGESTER 3 SLUDGE LEVEL RADAR	725LIT6503	Level Transmitter, Radar	008-I-016	Range: Mounting: Antenna: Coating: Sun Shield: Orientation Zero Reference: Frequency: Hazardous Rating: Instrument Enclosure: 0 - 50 feet, 8 inch flange 6 inch bullet nose, Teflon Provide sun shield Face north if possible but allow for access. Tank bottom 80 GHz Class 1, Division 1 Provide explosion proof instrumentation that does not require intrinsically safe circuitry to be intrinsically safe.	17208	13258
52	DC2 DIGESTER 3 DIGESTER GAS FLOW	725FIT6903, 725FE6903	Flow Element and Transmitter, Thermal Mass Flow	008-I-016	Range: Meter Size: Transmitter: Sun Shield: Stanchion: In-Situ Verification: Gas: Flow Element Mount: Retractable System: Hazardous Rating: Instrument Enclosure: 0 - 500 scfm, fit 6 inch pipe. Remote Mount Provide sun shield large enough to shade flow element (located on pipe). Mount stanchion south side of flow element facing north to provide shade. Factory Ready Digester Gas Side Mounted in pipe Retractable System. Teflon seals. Class 1, Division 1 Provide explosion proof instrumentation that does not require intrinsically safe circuitry to be intrinsically safe.	17305	13217, 17380

INSTRUMENT LIST

ITEM	LOOP DESCRIPTION	TAG / ACCESSORY	INSTRUMENT DESCRIPTION	P&ID	NOTES	SPEC	DETAIL
53	DC2 DIGESTER 3 SLUDGE LEVEL DIFFERENTIAL	725LIT6904 725LE6904A 725LE6904B	Level Transmitter, Differential Pressure	008-I-016	Range: (Low, High) Transmitter Mounting: Element Size: Diaphragm: Seal: Element Cable Length: Transmitter Cable Length: Hazardous Rating: Instrument Enclosure:	25 inch H20, 30 psi, Remote wall mount with sun shield 3 inch SS 150# flanges Ceramic, FFKM Kalrez 4079 100' between elements 35' from high side to transmitter Class 1, Division 1 Provide explosion proof instrumentation that does not require intrinsically safe circuitry to be intrinsically safe.	17406	17310, 17388

SECTION 17903
SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 I/O LIST

A. Use the descriptions on the I/O list for development of Shop Drawings.

3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. PLC I/O List.

END OF SECTION

DURHAM DIGESTER 3
PLC I/O LIST
NEW POINTS ON EXISTING SPARE I/O

PANEL CP10010

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DC 1 UPS	FAULT	FLT	740FLT6904	008-I-001	DI	6	note 1	note 1	note 1	N/A
DIGESTER GAS HOLDER TO DC 1 FLARE	FLOW	FI	740FI6904	008-I-001	AI	6	note 1	note 1	note 1	N/A
DIGESTER GAS HOLDER TO DC 1 PCV BYPASS VALVE	IN REMOTE	RE	740FCV6904	008-I-001	DI	6	note 1	note 1	note 1	N/A
DIGESTER GAS HOLDER TO DC 1 PCV BYPASS VALVE	POSITION	ZI	740FCV6904	008-I-001	AI	6	note 1	note 1	note 1	N/A
DIGESTER GAS HOLDER TO DC 1 PCV BYPASS VALVE	POSITION CMD	ZC	740FCV6904	008-I-001	AO	6	note 1	note 1	note 1	N/A
DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE	TEMPERATURE	TI	720TI6601A	008-I-015	AI	6	note 1	note 1	note 1	N/A
DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE OUTLET TEMPERATURE	TEMPERATURE	TI	720TI6601B	008-I-015	AI	6	note 1	note 1	note 1	N/A
DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE	TEMPERATURE	TI	720TI6602A	008-I-015	AI	6	note 1	note 1	note 1	N/A
DC 1 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE OUTLET TEMPERATURE	TEMPERATURE	TI	720TI6602B	008-I-015	AI	6	note 1	note 1	note 1	N/A

PANEL CP10010 TOTALS:
AI: 6
AO: 1
DI: 1
DO: 0

NOTES:
1. PLC I/O base, slot, and point will be assigned by Clean Water Services during Loop Drawing submittal review. Coordinate I/O assignments and wiring terminations with CWS prior to initiation of the wiring diagram effort. Final assignments will be made by CWS during review of wiring diagram submittal.
2. IP address will be assigned by Clean Water Services (CWS) programmer. Coordinate ethernet terminations with CWS prior to initiation of the wiring effort.

PANEL 715LCP6401

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
FOG FEED PUMP 3	TEMPERATURE	TAH	715TAH6406	008-I-009A	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	PRESSURE	PAH	715PAH6406	008-I-009A	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	RUNNING	ON	715P6406	008-I-009A	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	FAIL	OL	715P6406	008-I-009A	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	IN REMOTE	RE	715P6406	008-I-009A	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	RUN CMD	ONW	715P6406	008-I-009A	DO-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	SPEED CMD	SC	715P6406	008-I-009A	AO-ETH	16 RIO	N/A	N/A	N/A	note 2
FOG FEED PUMP 3	SPEED	SI	715P6406	008-I-009A	AI-ETH	16 RIO	N/A	N/A	N/A	note 2
HEAT TRACE CONTACTOR	RUN CMD	ONW	715HCC0001	008-I-009A	DO	16 RIO	note 1	note 1	note 1	N/A
FOG OFFLOADING HW RECIRCULATION PUMP	RUNNING	ON	715P6501	008-I-009B	DI	16 RIO	note 1	note 1	note 1	N/A
FOG OFFLOADING HW RECIRCULATION PUMP	FAIL	FLT	715P6501	008-I-009B	DI	16 RIO	note 1	note 1	note 1	N/A

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
FOG OFFLOADING HW RECIRCULATION PUMP	IN REMOTE	RE	715P6501	008-I-009B	DI	16 RIO	note 1	note 1	note 1	N/A
FOG OFFLOADING HW RECIRCULATION PUMP	RUN CMD	ONW	715P6501	008-I-009B	DO	16 RIO	note 1	note 1	note 1	N/A
SECONDARY HEAT LOOP FLOW CONTROL VALVE	POSITION CMD	ZC	715FCV6611	008-I-013	AO	16 RIO	note 1	note 1	note 1	N/A
SECONDARY HEAT LOOP FLOW CONTROL VALVE	POSITION	ZI	715FCV6611	008-I-013	AI	16 RIO	note 1	note 1	note 1	N/A
SECONDARY HEAT LOOP FLOW CONTROL VALVE	IN REMOTE	RE	715FCV6611	008-I-013	DI	16 RIO	note 1	note 1	note 1	N/A
DC2 SECONDARY HEAT LOOP PUMP 1	AMPS	II	715P6601	008-I-013	AI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	RUNNING	ON	715P6601	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	FAIL	FLT	715P6601	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	IN REMOTE	RE	715P6601	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	RUN CMD	ONW	715P6601	008-I-013	DO-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	SPEED CMD	SC	715P6601	008-I-013	AO-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 1	SPEED	SI	715P6601	008-I-013	AI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	AMPS	II	715P6602	008-I-013	AI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	RUNNING	ON	715P6602	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	FAIL	FLT	715P6602	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	IN REMOTE	RE	715P6602	008-I-013	DI-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	RUN CMD	ONW	715P6602	008-I-013	DO-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	SPEED CMD	SC	715P6602	008-I-013	AO-ETH	16 RIO	N/A	N/A	N/A	note 2
DC2 SECONDARY HEAT LOOP PUMP 2	SPEED	SI	715P6602	008-I-013	AI-ETH	16 RIO	N/A	N/A	N/A	note 2

PANEL 715LCP6401 TOTALS:

AI: 1
AO: 1
DI: 4
DO: 2

NOTES:

1. PLC I/O base, slot, and point will be assigned by Clean Water Services during Loop Drawing submittal review. Coordinate I/O assignments and wiring terminations with CWS prior to initiation of the wiring diagram effort. Final assignments will be made by CWS during review of wiring diagram submittal.
2. IP address will be assigned by Clean Water Services (CWS) programmer. Coordinate ethernet terminations with CWS prior to initiation of the wiring effort.

PANEL 725LCP9601

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DIGESTED SLUDGE PUMP 1 (EXISTING)	IN REMOTE	RE	20P10501	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	RUNNING	ON	20P10501	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	FAIL	FLT	20P10501	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	RUN CMD	ONW	20P10501	008-I-0100	DO-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	FLOW	FSL	20FSL10501	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	PRESSURE	PSH	20PSH10501	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	SPEED	SI	20P10501	008-I-0100	AI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 1 (EXISTING)	SPEED CMD	SC	20P10501	008-I-0100	AO-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	IN REMOTE	RE	20P10502	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	RUNNING	ON	20P10502	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	FAIL	FLT	20P10502	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	RUN CMD	ONW	20P10502	008-I-0100	DO-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	FLOW	FSL	20FSL10502	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	PRESSURE	PSH	20PSH10502	008-I-0100	DI-ETH	26	N/A	N/A	N/A	note 2
DIGESTED SLUDGE PUMP 2 (EXISTING)	SPEED	SI	20P10502	008-I-0100	AI-ETH	26	N/A	N/A	N/A	note 2

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DIGESTED SLUDGE PUMP 2 (EXISTING)	SPEED CMD	SC	20P10502	008-I-0100	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER OUTLET TEMPERATURE	TEMPERATURE	TI	725TI6611R	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 HOT WATER INLET TEMPERATURE	TEMPERATURE	TI	725TI6611S	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE FLOW	FLOW	FI	725FI6701	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE DISCHARGE TEMPERATURE	TEMPERATURE	TI	725TI6701B	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 1 SLUDGE INLET TEMPERATURE	TEMPERATURE	TI	725TI6701A	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER OUTLET TEMPERATURE	TEMPERATURE	TI	725TI6612R	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 HOT WATER INLET TEMPERATURE	TEMPERATURE	TI	725TI6612S	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE FLOW	FLOW	FI	725FI6702	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE DISCHARGE TEMPERATURE	TEMPERATURE	TI	725TI6702B	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 2 SLUDGE INLET TEMPERATURE	TEMPERATURE	TI	725TI6702A	008-I-010A	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION GRINDER 6	AMPS	II	715GDR6706	008-I-010A	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	SPEED	SI	715GDR6706	008-I-010A	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	SPEED CMD	SC	715GDR6706	008-I-010A	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	FORWARD	FWD	715GDR6706	008-I-010A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	REVERSE	REV	715GDR6706	008-I-010A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	FAIL	FLT	715GDR6706	008-I-010A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	IN REMOTE	RE	715GDR6706	008-I-010A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 6	RUN CMD	ONW	715GDR6706	008-I-010A	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION PUMP 6	IN REMOTE	RE	725P6706	008-I-010A	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 6	RUNNING	ON	725P6706	008-I-010A	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 6	FAIL	FLT	725P6706	008-I-010A	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 6	RUN CMD	ONW	725P6706	008-I-010A	DO	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER OUTLET TEMPERATURE	TEMPERATURE	TI	725TI6613R	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 HOT WATER INLET TEMPERATURE	TEMPERATURE	TI	725TI6613S	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE FLOW	FLOW	FI	725FI6703	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE DISCHARGE TEMPERATURE	TEMPERATURE	TI	725TI6703B	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION HEAT EXCHANGER 3 SLUDGE INLET TEMPERATURE	TEMPERATURE	TI	725TI6703A	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 FEED VALVE	FULLY OPEN	OP	725FV3801	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 FEED VALVE	FULLY CLOSED	CL	725FV3801	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 FEED VALVE	IN REMOTE	RE	725FV3801	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 FEED VALVE	OPEN CMD	OPW	725FV3801	008-I-010B	DO	26	note 1	note 1	note 1	N/A

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DC2 DIGESTER 3 FEED VALVE	CLOSE CMD	CLW	725FV3801	008-I-010B	DO	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION GRINDER 3	AMPS	II	715GDR6703	008-I-010B	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	SPEED	SI	715GDR6703	008-I-010B	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	SPEED CMD	SC	715GDR6703	008-I-010B	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	FORWARD	FWD	715GDR6703	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	REVERSE	REV	715GDR6703	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	FAIL	FLT	715GDR6703	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	IN REMOTE	RE	715GDR6703	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 3	RUN CMD	ONW	715GDR6703	008-I-010B	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	AMPS	II	715GDR6704	008-I-010B	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	SPEED	SI	715GDR6704	008-I-010B	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	SPEED CMD	SC	715GDR6704	008-I-010B	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	FORWARD	FWD	715GDR6704	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	REVERSE	REV	715GDR6704	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	FAIL	FLT	715GDR6704	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	IN REMOTE	RE	715GDR6704	008-I-010B	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION GRINDER 4	RUN CMD	ONW	715GDR6704	008-I-010B	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 SLUDGE RECIRCULATION PUMP 3	IN REMOTE	RE	725P6703	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 3	RUNNING	ON	725P6703	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 3	FAIL	FLT	725P6703	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 3	RUN CMD	ONW	725P6703	008-I-010B	DO	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 4	IN REMOTE	RE	725P6704	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 4	RUNNING	ON	725P6704	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 4	FAIL	FLT	725P6704	008-I-010B	DI	26	note 1	note 1	note 1	N/A
DC2 SLUDGE RECIRCULATION PUMP 4	RUN CMD	ONW	725P6704	008-I-010B	DO	26	note 1	note 1	note 1	N/A
FOG FEED	FLOW	FI	725FI6401	008-I-010B	AI	26	note 1	note 1	note 1	N/A
DC2 PRIMARY HEAT LOOP PUMP 1	AMPS	II	725P6601	008-I-011	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	SPEED	SI	725P6601	008-I-011	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	SPEED CMD	SC	725P6601	008-I-011	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	RUNNING	ON	725P6601	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	FAIL	FLT	725P6601	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	IN REMOTE	RE	725P6601	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 1	RUN CMD	ONW	725P6601	008-I-011	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	AMPS	II	725P6602	008-I-011	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	SPEED	SI	725P6602	008-I-011	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	SPEED CMD	SC	725P6602	008-I-011	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	RUNNING	ON	725P6602	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	FAIL	FLT	725P6602	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	IN REMOTE	RE	725P6602	008-I-011	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP 2	RUN CMD	ONW	725P6602	008-I-011	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 PRIMARY HEAT LOOP PUMP DISCHARGE PRESSURE	PRESSURE	PI	725PI6601B	008-I-011	AI	26	note 1	note 1	note 1	N/A
DC2 PRIMARY HEAT LOOP PUMP INLET PRESSURE	PRESSURE	PI	725PI6601A	008-I-011	AI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 3	TEMPERATURE SP	TC	725BLR6623	008-I-011A	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 3	RUNNING	ON	725BLR6623A	008-I-011A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 3	FAIL	FLT	725BLR6623A	008-I-011A	DI-ETH	26	N/A	N/A	N/A	note 2

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DC2 HW BOILER 3	SPEED	SI	725BLR6623	008-I-011A	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 3	RUN CMD	ONW	725BLR6623	008-I-011A	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 3 PUMP	RUNNING	ON	725BLR6623B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 3 PUMP	FAIL	FLT	725BLR6623B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 3 PUMP	IN REMOTE	RE	725BLR6623B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 4	TEMPERATURE SP	TC	725BLR6624	008-I-011A	AO-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 4	RUNNING	ON	725BLR6624A	008-I-011A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 4	FAIL	FLT	725BLR6624A	008-I-011A	DI-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 4	SPEED	SI	725BLR6624	008-I-011A	AI-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 4	RUN CMD	ONW	725BLR6624	008-I-011A	DO-ETH	26	N/A	N/A	N/A	note 2
DC2 HW BOILER 4 PUMP	RUNNING	ON	725BLR6624B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 4 PUMP	FAIL	FLT	725BLR6624B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 HW BOILER 4 PUMP	IN REMOTE	RE	725BLR6624B	008-I-011A	DI	26	note 1	note 1	note 1	N/A
DC2 BUILDING HWS TEMPERATURE	TEMPERATURE	TI	725TI6616	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 BUILDING HEATING FLOW CONTROL VALVE	POSITION	ZI	725FCV6616	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 BUILDING HEATING FLOW CONTROL VALVE	POSITION CMD	ZC	725FCV6616	008-I-012	AO	26	note 1	note 1	note 1	N/A
DC2 BUILDING HEATING FLOW CONTROL VALVE	IN REMOTE	RE	725FCV6616	008-I-012	DI	26	note 1	note 1	note 1	N/A
DC2 IPS BUILDING HWS TEMPERATURE	TEMPERATURE	TI	725TI6617	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 IPS BUILDING HEATING FLOW CONTROL VALVE	POSITION	ZI	725FCV6617	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 IPS BUILDING HEATING FLOW CONTROL VALVE	POSITION CMD	ZC	725FCV6617	008-I-012	AO	26	note 1	note 1	note 1	N/A
DC2 IPS BUILDING HEATING FLOW CONTROL VALVE	IN REMOTE	RE	725FCV6617	008-I-012	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 1 FLOW CONTROL VALVE	POSITION	ZI	725FCV6618	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 1 FLOW CONTROL VALVE	POSITION CMD	ZC	725FCV6618	008-I-012	AO	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 1 FLOW CONTROL VALVE	IN REMOTE	RE	725FCV6618	008-I-012	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 2 FLOW CONTROL VALVE	POSITION	ZI	725FCV6619	008-I-012	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 2 FLOW CONTROL VALVE	POSITION CMD	ZC	725FCV6619	008-I-012	AO	26	note 1	note 1	note 1	N/A
DC2 DIGESTER HEATING PUMP 2 FLOW CONTROL VALVE	IN REMOTE	RE	725FCV6619	008-I-012	DI	26	note 1	note 1	note 1	N/A
DC2 ELECTRICAL ROOM TEMPERATURE	TEMPERATURE	TI	725TI9601	008-I-012A	AI	26	note 1	note 1	note 1	N/A
DC2 OUTSIDE AIR TEMPERATURE	TEMPERATURE	TI	725TI5001	008-I-012A	AO	26	note 1	note 1	note 1	N/A
DC2 ELECTRICAL ROOM AIR HANDLING UNIT	FAULT	FLT	725FLT5001	008-I-012A	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HEAT LOOP FLOW CONTROL VALVE	POSITION	ZI	725FCV6613	008-I-012A	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HEAT LOOP FLOW CONTROL VALVE	POSITION CMD	ZC	725FCV6613	008-I-012A	AO	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HEAT LOOP FLOW CONTROL VALVE	IN REMOTE	RE	725FCV6613	008-I-012A	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HOT WATER SUPPLY PUMP	IN REMOTE	RE	725P6613	008-I-012A	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HOT WATER SUPPLY PUMP	RUNNING	ON	725P6613	008-I-012A	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HOT WATER SUPPLY PUMP	FAIL	FLT	725P6613	008-I-012A	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 HOT WATER SUPPLY PUMP	RUN CMD	ONW	725P6613	008-I-012A	DO	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 MIXER	FAIL	FLT	725MXR6503	008-I-016	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 MIXER	RUNNING	ON	725MXR6503	008-I-016	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 MIXER	LOW FLOW	FSL	725MXR6503	008-I-016	DI	26	note 1	note 1	note 1	N/A

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DC2 DIGESTER 3 MIXER OIL PUMP	RUNNING	ON	725P9201	008-I-016	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 MIXER OIL PUMP	FAIL	FLT	725P9201	008-I-016	DI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 DIGESTER	LEVEL	LI	725LIT6903	008-I-016	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 DIGESTER GAS	PRESSURE	PI	725PIT6903	008-I-016	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 DIGESTER GAS	FLOW	FI	725FIT6903	008-I-016	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 DIGESTER	LEVEL	LI	725LIT6904	008-I-016	AI	26	note 1	note 1	note 1	N/A
DC2 DIGESTER 3 NPW HEAT TRACE	RUN CMD	ONW	725HT6921	008-I-016	DO	26	note 1	note 1	note 1	N/A

PANEL 725LCP9601 TOTALS:

AI: 30
AO: 6
DI: 32
DO: 7

NOTES:

1. PLC I/O base, slot, and point will be assigned by Clean Water Services during Loop Drawing submittal review. Coordinate I/O assignments and wiring terminations with CWS prior to initiation of the wiring diagram effort. Final assignments will be made by CWS during review of wiring diagram submittal.
2. IP address will be assigned by Clean Water Services (CWS) programmer. Coordinate ethernet terminations with CWS prior to initiation of the wiring effort.

PANEL 750LCP3501

EQUIPMENT DESCRIPTION	FUNCTION	FUNCTION CODE	TAG	P&ID	TYPE	PLC	BASE	SLOT	POINT	ADDRESS
DIGESTER FEED TO DC1 VALVE	FULLY OPEN	OP	750FV3811	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED TO DC1 VALVE	FULLY CLOSED	CL	750FV3811	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED TO DC1 VALVE	IN REMOTE	RE	750FV3811	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED TO DC1 VALVE	OPEN CMD	OPW	750FV3811	008-I-014	DO	6	note 1	note 1	note 1	N/A
DIGESTER FEED TO DC1 VALVE	CLOSE CMD	CLW	750FV3811	008-I-014	DO	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC1 VALVE	FULLY OPEN	OP	750FV3812	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC1 VALVE	FULLY CLOSED	CL	750FV3812	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC1 VALVE	IN REMOTE	RE	750FV3812	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC1 VALVE	OPEN CMD	OPW	750FV3812	008-I-014	DO	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC1 VALVE	CLOSE CMD	CLW	750FV3812	008-I-014	DO	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC2 VALVE	FULLY OPEN	OP	750FV3813	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC2 VALVE	FULLY CLOSED	CL	750FV3813	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC2 VALVE	IN REMOTE	RE	750FV3813	008-I-014	DI	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC2 VALVE	OPEN CMD	OPW	750FV3813	008-I-014	DO	6	note 1	note 1	note 1	N/A
DIGESTER FEED PUMP 2 TO DC2 VALVE	CLOSE CMD	CLW	750FV3813	008-I-014	DO	6	note 1	note 1	note 1	N/A

PANEL 750LCP3501 TOTALS:

AI: 0
AO: 0
DI: 9
DO: 6

NOTES:

1. PLC I/O base, slot, and point will be assigned by Clean Water Services during Loop Drawing submittal review. Coordinate I/O assignments and wiring terminations with CWS prior to initiation of the wiring diagram effort. Final assignments will be made by CWS during review of wiring diagram submittal.
2. IP address will be assigned by Clean Water Services (CWS) programmer. Coordinate ethernet terminations with CWS prior to initiation of the wiring effort.

PART 4

DRAWINGS