Woodland Fish Passage Project

Bid Documents

Prepared for:

Maine Department of Marine Resources

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May 9, 2025

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SUMMARY OF WORK

PART 1 - GENERAL

1.01. SUMMARY

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3. Location of Project Site.

4. Work by Property Owner, Woodland Pulp LLC (Property Owner or Woodland Pulp).

5. Access to Site.

6. Permits.

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8. Fences.

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1.02. WORK COVERED BY CONTRACT DOCUMENTS

A. General

1. This Section describes the Project and provides an overview of the extent of the Work to be performed under the General Contract.

2. Detailed requirements and extent of Work are stated in this Section and the drawings and specifications of this Project Manual.

B. Furnish all materials, equipment, supplies, and appurtenances; provide all construction equipment and tools; and perform all necessary labor, supervision and shipping to complete the proposed Work within the Contract Time at the site of the existing Woodland Hydroelectric Station.

C. Coordinate the progress of the Work, including coordination between trades, subcontractors, suppliers, sole-sourced equipment manufacturers, public utilities, operation of hydropower and flow regulating infrastructure, and Maine DMR to ensure the progress of the Work.

D. The Work of the Project is defined by the Contract Documents and consists of, but is not limited to, the following:

1. Mobilization and Demobilization;
2. Quality Control;
3. Record Documents;
4. Environmental Controls;
5. Cofferdams;
6. Dewatering;
7. Earthwork;
8. Rock Excavation;
9. Concrete Demolition;
10. Cast-in-Place Concrete at Fish Lift, Fish Ladder, Exit Flume, Bridge Abutments, and Flood Walls;
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15. Fish Hopper;
16. Cranes and Hoists at Fish Lift;
17. Gates and Screens at Fish Lift and Fish Ladder;
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19. Electrical Equipment Enclosure;

20. Electrical Activities (Systems?) at Fish Lift, Fish Ladder, and Flumes;

21. System Testing and Start-Up

1.03. COMMENCEMENT, PROSECUTION, AND COMPLETION OF WORK

A. The Contractor shall commence Work under this Contract, prosecute the Work diligently, and complete the various parts of the Work ready for use by Maine DMR not later than the dates delineated in the final, executed version of the Agreement.

1. Key Schedule Dates are provided in the Invitation to Bid; however, the dates stated in the final, executed version of the Agreement shall be the contractually-binding dates.

B. Substantial Completion

1. Substantial Completion shall be as defined in the Agreement.

2. Substantial Completion shall be documented by the Engineer.

C. Final Completion

1. Final Completion shall be as defined in the Agreement.

2. Final Completion shall be documented by the Engineer.

1.04. LOCATION OF PROJECT SITE

A. The Project is located in the Town of Baileyville on the St. Croix River in Washington County, Maine.

1.05. WORK BY PROPERTY OWNER

A. Normal day-to-day operations of the Property Owner’s mill will be ongoing. Hydropower and flow regulating infrastructure may also be operating. Construction shall not isolate or interrupt existing activities, including, but not limited to Property Owner's staff and/or contract operations, equipment operation, maintenance and repair, except as specifically described herein.

1.06. ACCESS TO SITE

A. Construction activities, schedules, and equipment cannot negatively impact Property Owner’s ability to operate hydropower and flow regulating infrastructure.

B. General

1. Contractor shall have full use of areas of Project Site for construction operations during the construction period, as delineated on the Drawings and as defined in the Agreement. Contractor's use of Project Site within designated areas for construction is limited only by Property Owner's operations and right to perform work. Contractor to provide access at all times to all existing hydropower and flow regulating infrastructure and equipment for operation and maintenance by Property Owner.

C. Use of Site

1. Limit use of Project Site to Construction Limits indicated on Drawings except as directed or authorized by Woodland Pulp to limit impacts to its operations. Use due care in placing construction tools, equipment, excavated materials, and construction materials and supplies, so as to cause the least possible damage to property. Do not disturb portions of Project Site beyond areas in which the Work is indicated.

D. Property Owner or Maine DMR Limited Occupancy of Completed Areas of Construction

1. Property Owner and/or Maine DMR reserve(s) the right to occupy, place, and install equipment in completed portions of the Work, prior to Substantial Completion of the Work, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and limited occupancy shall not constitute acceptance of the total Work.

a. Engineer will prepare a Certificate of Substantial Completion for the Work to be occupied prior to Maine DMR's acceptance of the completed Work.

b. Before limited Property Owner and/or Maine DMR occupancy, mechanical and electrical systems shall be fully operational and required tests and inspections shall be successfully completed. Upon occupancy, Property Owner and/or Maine DMR will operate and maintain mechanical and electrical systems serving occupied portions of Work.

c. Upon occupancy, Property Owner and/or Maine DMR will assume responsibility for maintenance and custodial service for occupied portions of Work.

1.07. PERMITS

A. All necessary permits, including those applied for by Maine DMR shall be received for work to begin, including:

1. United States Army Corps of Engineers (USACE)

2. Maine General Permit (GP) Pre-Construction Notification (PCN)

3. Consultation with Maine Historic Preservation Commission (MHPC)

4. Consultation with Tribal Historic Preservation Offices (THPO) (for the five federally recognized tribes of Maine)

5. USFWS Endangered Species Identification and Protection

6. NOAA Critical Habitat Designations

7. International Joint Commission (UC) (not required)

8. National Environmental Policy Act (NEPA)

9. Maine Department of Environmental Protection (MEDEP) Maine Construction General Permit (MCGP)

10. Consultation with MDIFW

11. MEDEP Maine Waterway Development and Conservation Act (MWDCA)

12. Town of Baileyville, ME Shoreland Zoning Ordinance

Any other required permit or authorization not specifically listed in this section is the responsibility of the Contractor to obtain. All permits and authorization obtained by the Contractor shall be provided to Maine DMR and copies of each permit shall be maintained on the job site.

1.08. EASEMENTS AND RIGHT-OF-WAY

A. All work has been negotiated to occur on Woodland Pulp's property, but Contractor is responsible to obtain written permission from Woodland Pulp and supply to Maine DMR prior to mobilization.

1.09. FENCES

A. Maintain all fences affected by the Work until completion of the Work, unless shown otherwise on the Drawings.

B. Do not relocate or dismantle fences which interfere with construction operations before obtaining written permission from the fence owner with an agreement as to the length of time the fence may be left relocated or dismantled, and re-establishment of fences.

C. Where fences must be maintained across the construction access, install adequate, lockable gates.

D. Keep gates closed and locked when not in use.

1.10. FIELD ENGINEERING

A. Employ a Professional Land Surveyor registered in the State of Maine and acceptable to the Engineer.

B. Contractor to locate, mark, and protect survey control and reference points.

C. Control datum for survey is that established by the design survey and shown on Drawings.

D. Provide field engineering services. Establish elevations, lines, and levels, utilizing recognized engineering survey practices.

E. Submit certificate signed by the Professional Land Surveyor that the elevations and locations of the Work are in conformance with the Contract Documents.

1.11. LINES AND GRADES

A. Construct all Work to the lines, grades, and elevations indicated on the Drawings:

   1. Remove and reconstruct improperly-located Work.

B. Horizontal and vertical control points are shown on the Drawings:

   1. Use these points as datum for the Work.

   2. Contractor shall provide competent personnel and tools, stakes, and other materials as Engineer may require in establishing or designating control points, in establishing construction easement boundaries as applicable, or in checking layout survey, and measurement work performed by Contractor.

C. Provide all additional survey, layout, and measurement work required:

   1. Work performed by a qualified professional engineer or registered land surveyor acceptable to Engineer.

   2. Locate and protect control points prior to starting site work, and preserve all permanent reference points during construction:

      a. Make no changes or relocations without prior written notice to Engineer.

      b. Report to Engineer when any reference point is lost or destroyed or requires relocation because of necessary changes in grades or locations.

      c. Replace Project control points which may be lost or destroyed, by a Professional Land Surveyor. Establish replacements based on original survey control.

3. Establish lines and levels, locate and lay out, by instrumentation and similar appropriate means.

4. From time to time, verify layouts by the same methods.

5. Maintain a complete, accurate log of all control and survey work as it progresses.

6. On request of Engineer, submit documentation to verify accuracy or field engineering work.

1.12. REGULATORY REQUIREMENTS

A. Comply with all federal, state, and local laws, regulations, codes, permits, and ordinances applicable to the Work.

B. References in the Contract Document to local codes shall mean the codes in effect in the State of Maine and Washington County.

C. Other standards and codes which apply to the Work are designated in the Specifications.

1.13. COORDINATION WITH WOODLAND PULP

A. The existing mill and hydroelectric station are expected to be in operation during most of the construction of the fish passage facilities. The Contractor shall coordinate with Woodland Pulp all key construction activities, including the initiation of mobilization, initiation of cofferdam construction, and for cofferdam removal. Construction of the temporary cofferdam shall be coordinated with Woodland Pulp including lock-out, tag-out of applicable gates and equipment by Woodland Pulp. The Contractor must coordinate with Woodland Pulp for any activities that will block access drives, walkways or facilities needed by Woodland Pulp for operation, and must provide pedestrian and vehicular access as required to the station throughout the construction period.

B. The Contractor shall coordinate impacts to hydroelectric station facilities necessary for the Contractor’s work activities a minimum of seven (7) calendar days, excluding observed holidays, notice in advance. The Contractor shall only request operations support from Woodland Pulp during its normal working hours Monday through Thursday; Fridays will only be made available with advance authorization from Woodland Pulp.

C. Wiring: The Contractor shall coordinate with Woodland Pulp the wiring from the power source to the power panel and from the panel to all equipment for both temporary power and permanent power.

D. Site Access: Coordinate with Woodland Pulp for access to the hydroelectric station, lay down areas, storage areas, temporary fencing and gate locations, temporary facility locations and utility routes, and/or vehicular and pedestrian access to job trailer(s) and work areas.

E. Shop Facilities: The Contractor shall provide access to its manufacturing and fabrication facilities to the Engineer for inspection of any project Work.

F. Monthly Progress Report: The Contractor shall prepare a detailed construction schedule and shall submit to the Engineer, Maine DMR, and Woodland Pulp a monthly report of progress against such schedule, activities planned for the next month, deviations from the schedule, and any anticipated problems.

G. Commissioning and Start-up: Commissioning and start-up of each piece of equipment and of the entire system shall be the responsibility of the Contractor. The system testing and start-up shall be a joint effort of the Contractor and Woodland Pulp requiring very close coordination. The Contractor shall appraise Woodland Pulp of all start-up activities with reasonable advance notice but no less than seven (7) calendar days, exclusive of holidays, in advance so Woodland Pulp may observe the start-up. The Contractor shall coordinate such activities with Woodland Pulp regarding the station safety procedures, such as lockout-tagout and other tagging procedures.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 20 00

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

A. This Section describes the measurement of and payment for the Work to be completed under the items listed on the Price Component Schedule.

PART 2 - WORK LISTED IN THE SCHEDULE OF WORK ITEMS

A. Work under this Contract will be paid on a unit price or lump-sum basis as outlined on the Price Component Schedule for the quantity of Work installed.

B. The unit prices and lump-sum prices include full compensation for furnishing the labor, materials, tools, equipment, and incidental expenses to do the Work required in completing the Project included in the Contract Documents.

C. The application for payment will be for a specific item based on the percentage completed or quantity installed. The percentage complete will be based on the value of the partially completed Work relative to the value of the item when entirely completed and ready for service.

D. Contractor shall submit a Schedule of Values providing a breakdown of Price Component Schedule items as perceived by the Contractor and an accompanying proposed Payment Schedule identifying cost loading and/or milestones to be completed for payment applications over the Contract duration. The Schedule of Values and Payment Schedule are subject to agreement by Maine DMR.

PART 3 - WORK NOT LISTED IN THE SCHEDULE OF WORK ITEMS

A. The General Conditions and items in the Special Provisions, general requirements, and specifications which are not listed in the schedule of work items of the Price Component Schedule are, in general, applicable to more than one listed work item, and no separate work item is provided therefor. Include the cost of work not listed but necessary to complete the project designated in the contract documents in the various listed work items of the Price Component Schedule.

B. The Price Component Schedule is intended to establish a total cost for the work in its entirety. Should the Contractor feel that the cost for the work has not been established by specific items in the Price Component Schedule, identify those specific items that are not reflected in the schedule and include the cost for that work in some related item so that the Proposal for the project reflects the total cost for completing the work in its entirety.

PART 4 - ITEM DESCRIPTIONS – REFER TO PRICE COMPONENT SCHEDULE

4.01. MOBILIZATION AND DEMOBILIZATION

Item Description: Work shall include costs associated with mobilization and demobilization. Neither Project Management, Bonds, nor Insurance are covered by this item; refer to other items specific for that Work.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: Payment shall be at the lump sum price provided in the Price Component Schedule. This price shall not exceed 5 percent of the Total Cost shown on the Price Component Schedule. Payment shall be made after all conditions stated in the Price Component Item Description have been completed, less any applicable retention, in accordance with the Contract.

(a) Partial payment, 40 percent, may be submitted with the first progress payment upon physical mobilization to the site.

(b) Partial payment, 40 percent, will be paid when the Contractor's site office has been established.

(c) The remaining payment, 20 percent, shall be paid as a lump-sum after the issuance of the Final Completion Letter, the Contractor has demobilized, and the site has been restored.

4.02. PROJECT MANAGEMENT AND QUALITY CONTROL

Item Description: Work shall include but not be limited to project initiation, scheduling, permits, submittals, requests for information (RFIs), budget and invoice tracking, meetings, communications, procurement of a Field Quality Control Testing firm, per Section 01 40 00, and coordination of inspections, testing, and results.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: Payment shall be made at the contract lump-sum price and shall be divided equally throughout the length of the Contract or as proposed and approved by Maine DMR in Contractor’s Payment Schedule, less any applicable retention, in accordance with the Contract.

4.03. RECORD DOCUMENTS

Item Description: Work shall include furnishing Record Documents in accordance with Section 01 78 39.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: Payment shall be made in the following manner, less any applicable retention, in accordance with the Contract:

(a) 50 percent of the contract lump sum Price after the Contractor submits Record Drawings for initial review by Maine DMR's Representative.

(b) 50 percent of the contract lump sum Price after the Contractor submits final Record Drawings incorporating or responding to the comments of Maine DMR's Representative.

4.04. ENVIRONMENTAL CONTROLS

Item Description: Work shall include the construction, installation, maintenance, and removal of temporary water quality, erosion, and sediment control best management practices (BMPs), as necessary, to control surface water runoff, groundwater seepage, and dewatering system discharges at the construction site to protect the overall project site and the river. Work shall be in accordance with Section 01 57 13 and as shown on the Drawings.

(1) Measurement: No specific measurement for payment will be made, but Contractor shall compare incurred expenses for deployment of environmental controls against its approved Water Quality, Sediment, and Erosion Control Plan to ensure percentages proposed for progress payments are reasonable.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor’s Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.05. COFFERDAMS

Item Description: Work shall include the design, fabrication, installation, and removal of cofferdams to prevent water from the River entering the area of Work. Work shall be in accordance with Section 31 23 19 and as shown on the Drawings.

(1) Measurement: Percent completion of Work shall be measured against Contractor's Payment Schedule, such as proposed milestone payments for design upon acceptance or for materials upon delivery, to be reviewed and approved by Maine DMR.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.06. DEWATERING

Item Description: Work shall include furnishing all materials, labor, and equipment required to complete all dewatering Work as specified in Section 31 23 19. Any crushed rock, pea gravel, or similar material used in the trench as part of the dewatering operation shall be included in this Item.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract..

4.07. EARTHWORK

Item Description: Work shall include earth excavation and backfill as shown on the Drawings and as specified in Section 31 30 00. Rock excavation is not included in this item.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.08. ROCK EXCAVATION

Item Description: Work shall include rock excavation as shown on the Drawings and as specified in Section 31 30 00.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item. Measurement for change order payment at unit prices will be made by cubic yard removed.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

Payment under change order unit pricing shall be made at the price per cubic yard in Part II of the Price Component Schedule.

4.09. CONCRETE DEMOLITION

Item Description: Work shall include items delineated in Section 02 41 00 and associated items shown on the Drawings.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item. Measurement for change order payment at unit prices will be made by counting.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

Payment under change order unit pricing shall be made at the price per cubic yard in Part II of the Price Component Schedule.

4.10. CAST-IN-PLACE CONCRETE

Item Description: Work shall include furnishing and installing all cast-in-place concrete at the bridge abutments, flood walls, fish lift, fish ladder, exit flume, and slabs on grade as shown on the Drawings and as specified in Division 03.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item, but percent completion may at any time be compared to placed quantities measured by cubic yard for acceptance by Maine DMR.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed, less any applicable retention, in accordance with the Contract. Percentage completion for progress payments shall be based on actual concrete placed in alignment with Contractor's Payment Schedule and passing at a minimum testing and inspection requirements up to and including review and

acceptance of 7-day compressive strength testing results. Maine DMR's acceptance of the percentage completed and submitted for progress payment shall not relieve the Contractor of its obligation for cast-in-place concrete to meet all testing and inspection requirements. The Contractor's final progress payment for this item shall not be submitted until all respective cleaning and finishing has been completed.

4.11. MICROPILES

Item Description: Work shall include furnishing and installing all micropiles as shown on the Drawings and as specified in Section 31 33 00.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item.

(2) Payment: The pay quantity for the lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.12. STRUCTURAL STEEL FRAMING AT FISH LIFT

Item Description: Work shall include furnishing and installing all structural steel framing at the fish lift as shown on the Drawings and as specified in Section 05 12 00.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item. Measurement for change order payment at unit prices will be made by counting.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.13. EXIT FLUME AND BYPASS FLUME STRUCTURAL STEEL

Item Description: Work shall include furnishing and installing all structural steel at the exit flume and bypass flume as shown on the Drawings and as specified in Section 05 12 00.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item. Measurement for change order payment at unit prices will be made by counting.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.14. DOWNSTREAM PIPE SYSTEMS AND STEEL FRAMING

Item Description: Work shall include furnishing and installing the downstream piping, coatings, associated pipe cradles, and steel framing support as shown on the Drawings and as specified in Section 05 12 00 and 33 11 00.

(1) Measurement: No specific measurement for payment will be made for the lump sum Item. Measurement for change order payment at unit prices will be made by counting.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.15. AWS PIPE SYSTEMS AND STEEL FRAMING

Item Description: Work shall include furnishing and installing the AWS piping, coatings, associated pipe cradles, and steel framing support as shown on the Drawings and as specified in Section 05 12 00 and 33 11 00.

(1) Measurement: Measurement shall be made by counting.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.16. STAIRS, GRATING, LADDERS, RAILING, AND PLATFORMS

Item Description: Work shall include furnishing and installing all stairs, grating, ladders, and railing as shown on the Drawings and as specified in Section 05 50 00 and Division 06.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.17. FISH HOPPER

Item Description: Work shall include furnishing and installing the hopper, hopper gate with pneumatic piston, brail, rail bumpers, and ancillary equipment including pneumatic pipe, hose, and valves as shown on the Drawings and as specified in Section 05 50 00.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract. The Contractor's final progress payment for this item shall not be submitted until all associated equipment testing has been completed and accepted by Maine DMR, which excludes System Testing.

4.18. CRANES AND HOISTS AT FISH LIFT

Item Description: Work shall include furnishing and installing the hopper hoist and related lifting equipment, and all other required cranes and hoists as shown on the Drawings and as specified in Section 41 22 00.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract. The Contractor's final progress payment for this item shall not be submitted until all associated equipment testing has been completed and accepted by Maine DMR, which excludes System Testing.

4.19. GATES AND SCREENS

Item Description: Work shall include furnishing and installing all components of the wedge wire screen and air burst system, entrance gates, flow control gates, weir panels, baffle walls, upstream screens, V-gates, and isolation gates as shown on the Drawings and as specified in Sections 11 10 00, 35 20 13, and 35 20 16.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract. The Contractor's final progress payment for this item shall not be submitted until all associated equipment testing has been completed and accepted by Maine DMR, which excludes System Testing.

4.20. ACCESS ROAD

Item Description: Work shall include furnishing and installing the access road to the bridge as shown on the Drawings.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.21. ACCESS BRIDGE

Item Description: Work shall include furnishing and installing the access bridge support as shown on the Drawings and as specified in Section 32 34 00.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.22. ELECTRICAL EQUIPMENT ENCLOSURE

Item Description: Work shall include furnishing and installing electrical equipment enclosure as shown on the Drawings and as specified in Section 26 27 16.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.23. SYSTEM TESTING AND START-UP

Item Description: Work shall include testing and start-up of all equipment as shown on the Drawings and as specified in 01 75 16.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: The pay quantity for this lump sum Item shall be percentage of Work completed in alignment with Contractor's Payment Schedule at the time of billing, less any applicable retention, in accordance with the Contract.

4.24. BONDS AND INSURANCE

Item Description: Work shall include the procurement of the Contractor's Bonds and Insurance required for the Project.

(1) Measurement: No specific measurement for payment will be made.

(2) Payment: Payment shall be made at the lump sum price in the Price Component Schedule after proofs of such bonds and insurance have been provided to Maine DMR, less any applicable retention, in accordance with the Contract.

END OF SECTION

SECTION 01 32 16

CONSTRUCTION PROGRESS SCHEDULE

PART 1 - GENERAL

1.01. SECTION INCLUDES

A. Requirements for submittal of a critical path method (CPM) construction schedule and an associated schedule of values.

B. Development of the schedule, the cost loading of the schedule, monthly payment requisitions, and Project status reporting requirements of the Contract shall employ computerized CPM scheduling. The CPM schedule shall be cost-loaded, based on the schedule of values or unit bid prices or combination thereof.

1.02. INITIAL SCHEDULE SUBMITTALS

A. Submit two short-term schedule documents at least seven calendar days in advance of the Pre-Construction Meeting and as described in the subsection on “Submittals”, herein, 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. Submit (1) a 60-day narrative plan of operation, describing in detail narrative how Contract operations will be conducted, (2) a Project overview bar-chart type plan for all Work as indicated below, and (3) a progressive 3-week look-ahead schedule.

1. 60 Day Narrative Plan of Operation

a. During the initial 60 days of the Contract time, conduct Contract operations in accordance with the 60d ay detail narrative and bar chart plan of operation. The bar chart shall show the accomplishment of the Contractor's early activities (mobilization items, 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).

2. Comprehensive Project Overview Bar Chart

a. The comprehensive overview bar chart shall indicate the major components of the Project 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 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 potholing, excavation, bedding and pipe installation, backfilling, surface restoration, structures, relocations, improvements, and other important Work for each major facility within the overall Project scope. Indicate planned durations and start dates for each Work item subdivision. Plot each major component and subdivision component on time scale sheets not to exceed 36- by 60-inches in size. Do not use more than four sheets to represent this overview information.

3. 3-Week Look-Ahead

a. This schedule is to provide an overview of activities for the next three weeks. This is to inform all parties of concrete pouring, testing, equipment installation, etc., which will be reviewed at Construction Progress Meetings.

B. The Engineer and the Contractor shall meet to review and discuss the narrative 60 day plan of operations and Project overview bar chart within 10 calendar days after they have been submitted. The Engineer's review and comment on the schedules shall be limited to Contract conformance. Make corrections to the schedules necessary to comply with the Contract requirements and adjust the schedules to incorporate any missing information requested by the Engineer.

C. Satisfactory incorporation of the Engineer's comments shall be a condition for progress payments.

1.03. CPM PROGRAM

A. Use PRIMAVERA (R) P-3 or 4, SURETRAK(R), MS Project, or equivalent computer software for the CPM schedule, as approved by the Engineer. If software other than one of the programs named above is used, provide licensed copy and training to Engineer.

1.04. SUBMITTALS

A. Within three calendar days of the date of the Notice to Proceed, submit a written statement of CPM capability, verifying that the Contractor has qualified in-house personnel capable of using the CPM technique or that the Contractor employs a qualified CPM consultant. The statement shall identify the individuals who will perform the CPM scheduling and provide those individuals' detailed resumes. Capability shall be verified by detailed description of construction projects and references on which the individuals have successfully applied computerized CPM and shall include at least two projects of similar nature, scope, and value not less than one-half the total bid price of this Project. The statement shall also provide the contact persons for the referenced projects with current telephone and address information.

B. Submit an initial schedule within 15 calendar days of the date of the Notice to Proceed. If revisions are required to this initially submitted schedule, resubmit a revised schedule within seven calendar days after the Contractor receives the returned copy.

C. Submit graphic network diagram and tabulated schedules within 30 calendar days of the date of the Notice to Proceed.

D. Within 10 calendar days after the conclusion of Engineer's review, revise the network diagram and resubmit the network diagram and a tabulated schedule produced there from. The revised network diagram and tabulated schedule will be reviewed and accepted or rejected by Engineer within seven calendar days after receipt. The network diagram and tabulated schedule when accepted by Engineer shall constitute the Project Work schedule unless a revised schedule is required due to substantial changes in the Work or a change in Contract time, delinquency by Contractor requiring a recovery schedule, or as otherwise provided herein below. Activities not occurring as scheduled are delinquent if they begin after early start or they finish after early finish.

E. Submit a copy of the updated schedule, clearly showing progress made and actual "S" curves, on a monthly basis along with the Application for Payment.

F. Schedule submittals to the Engineer shall include an electronic copy of a CPM-type construction schedule, generally as outlined in the Associated General Contractors of America publication “The Use of CPM in Construction”, accompanied by a PDF copy.

G. Submit a preliminary schedule of values for the major components of the Work within 10 calendar days of the date of the Notice to Proceed.

H. Prepare and submit a detailed schedule of values to the Engineer within 30 calendar days from the date of the Notice to Proceed.

I. Contractor shall update the 3-week look-ahead schedule and submit to the Engineer no later than close of business each Thursday for review each Friday or one business day in advance of each Construction Progress Meeting as mutually agreed between Contractor and the Engineer.

1.05. PROJECT INFORMATION

A. Each network diagram, schedule, and report tabulation shall be prefaced with the following summary data:

1. Project name and number.

2. Contractor.

3. Type of tabulation (initial or updated).

4. Project duration.

5. Project Contract completion date.

6. Projected completion date.

7. Variance analysis per activity.

1.06. GRAPHIC NETWORK DIAGRAM AND TABULATED SCHEDULES

A. The completed schedule shall include a graphic network and tabulated schedules with the graphic network displayed on a sheet with a minimum size of 11-by 17-inches and a maximum size of 36- by 60-inches. The graphic network shall be the precedence diagram method (PDM). It may be divided into two or more sheets, if necessary, provided that all sheets are properly referenced. Notation on each activity arrow shall include a brief Work description and an estimate of the time duration of the Work. Show a calendar along the full length of each sheet. Plot each activity so that the beginning and completion dates can be readily determined by comparison to the calendar scale. Show activities using symbols and/or color that clearly designate whether it is a critical path or noncritical activity. Noncritical path activities shall show estimated Work time and free float time.

B. Float Time

1. Definition: Unless otherwise provided herein, float as referenced in these documents is 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, that activity then becomes part of the critical path and controls the end date of the project. Thus, the delay of the noncritical path activity beyond its float period will cause delay to the Project itself.

2. Float Ownership: Neither Maine DMR 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.

C. Display time at the top of the schedule, reading left to right, with no greater than weekly divisions.

D. The schedule shall indicate dates for important activities (milestone dates) including:

1. A logical succession of Work from start to finish. This logical succession, when accepted, is the Contractor's Work plan and is only designated as early start to accommodate standard computerized systems.

2. Detailed definition of each activity.

3. A logical flow of Work crews/equipment (crews are to be defined by labor category and labor hours; equipment by type and hours).

4. Shop drawing submittals and reviews.

5. Decisions.

6. Product procurement and delivery.

7. Beginning and completion of each element of construction.

8. Critical coordination dates.

9. Submittal of record drawings and equipment manuals.

10. Cleanup, final inspection, etc.

11. Any Project milestones or phases of Work that affect important dates.

E. Submit:

1. Activity sort by early start, organized by related elements.

2. Activity sort by float, organized by related elements.

3. Activity sort by predecessor/successor.

4. Narrative description of the logic and reasoning of the schedule.

5. Resource allocation by activity.

6. List of cost-loaded activities that identifies specific cost amount for each activity in the CPM schedule.

F. Show constraints between interrelated activities.

G. The initial schedule shall include the following minimum data for each activity:

1. Activity numbers.

2. Estimated duration.

3. Activity description.

4. Early start date (calendar dated).

5. Early finish date (calendar dated).

6. Status (whether critical).

7. Float.

8. Cost of activity.

9. Other resources including equipment hours by type, labor by craft or crew, and materials by units.

H. Where float time exists in activities, show the activities with early start/early finish times.

I. The schedule shall include a title block with the Project title, the Contractor's business name, the date of submittal or revision, and the signature of the Contractor's authorized representative attesting to his review and accuracy of the submittal.

J. The duration indicated for each activity shall be in calendar days and shall represent the single best time considering the scope of the Work and resources planned for the activity including time for inclement weather. Except for certain non-labor activities, such as curing concrete or delivering materials, activity durations shall not exceed two weeks, be less than one day, or exceed $25,000 in value unless otherwise accepted by the Engineer.

1.07. CONSTRUCTION SCHEDULE PROGRESS

A. If the Contractor's progress has fallen behind the accepted construction schedule, the Contractor shall take such steps as may be required, including increasing the number of personnel, shifts, overtime operations, days of Work, and amount of construction equipment until such time as the Work is back on schedule. Increased costs of any accelerated Work program shall be paid for by the Contractor.

B. Submit such recovery schedule within 10 calendar days upon written request by Engineer.

C. Revisions to the Work Hours, Working Days, and number of shifts shall be coordinated with Woodland Pulp.

1.08. ACCEPTANCE

A. The finalized schedule will be acceptable to the Engineer when it provides an orderly progression of the Work to completion in accordance with the Contract requirements, adequately defines the Contractor's Work plan, provides a workable arrangement for processing the submittals in accordance with the Project specification requirements, and properly allocates resources (labor, equipment, and costs) to each activity (free of unbalances in resources). When the network diagram and tabulated schedule have been accepted, submit to Engineer a final PDF tabulated schedule in which the activities have been sequenced by activity numbers final PDFs of all reports required by this specification.

B. Also submit electronic data compatible with the specified CPM program to generate network diagrams and schedule reports identical to the PDF versions submitted.

C. Review of the Contractor's Project schedule is for conformance to the requirements of the Contract Documents only. Review by the Engineer of the Contractor's Project schedule does not relieve the Contractor of any of its responsibility whatsoever for the accuracy or feasibility of the Project schedule, or of the Contractor's ability to meet the interim milestone date(s) and the Contract completion date, nor does such review and acceptance imply or expressly warrant, acknowledge, or admit the reasonableness of the logic, durations, labor, or equipment loading of the Contractor's Project schedule.

1.09. REVISIONS OR UPDATES TO CONSTRUCTION SCHEDULE

A. Submit a revised or updated construction schedule by the third day of each month. The data date shall be the 25th of the preceding month. Revise or update the schedule upon the occurrence of any of the following:

1. When delay in completion of any activity or group of activities indicates an overrun of the Contract time or control point requirement by 10 working days or ten percent of the remaining duration, whichever is less.

2. Delays in submittals, deliveries, or Work suspension or stoppage are encountered which make replanning or rescheduling of the Work necessary.

3. The schedule does not represent the actual prosecution and progress of the Project as being performed in the field and progress for any activity is five working days behind the current schedule.

4. The Contractor will be performing Work at an earlier date than is shown on the schedule and the Work will require additional inspection and/or testing personnel.

B. In the event of any change to the Contract, submit a time analysis of the effect on the critical path. If the Contractor maintains there is no impact, submit a statement to that effect.

C. The cost of revisions to the construction schedule resulting from agreed upon and approved Contract changes shall be included in the cost for the change in the Work and shall be paid as part of the total cost of the change through the Contract allowable percentages for changed Work.

D. The cost of revisions to the construction schedule not resulting from authorized changes in the Work shall be the responsibility of the Contractor.

E. revisedSubmittal of the updated construction shall be a condition for approval of the progress payment.

1.10. PRELIMINARY SCHEDULE OF VALUES

A. The preliminary schedule of values listing shall include, at a minimum, the proposed value for the items delineated in the Bid Schedule.

B. The Contractor and Engineer shall meet and jointly to review the preliminary schedule of values and make any adjustments in value allocations if, in the opinion of the 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 Engineer may require reallocation of major Work components from items in the above listing if, in the opinion of the Engineer, such reallocation is necessary. This review and any necessary revisions shall be completed within 15 calendar days from the date of the notification of the required reallocation.

1.11. DETAILED SCHEDULE OF VALUES

A. Base the detailed schedule of values on the accepted preliminary schedule of values for major Work components. Because the ultimate requirement is to develop a detailed schedule of values sufficient to determine appropriate monthly progress payment amounts through cost loading of the CPM schedule activities, provide sufficient detailed breakdown separately to meet this requirement. The Engineer shall be the sole judge of acceptable numbers, details, and description of values established. If, in the opinion of the Engineer, a greater number of schedule of values items than proposed by the Contractor is necessary, the Contractor shall add the additional items so identified by the Engineer as a condition to processing the payment requests.

B. Other Work not specifically included in the above major Work component values shall be broken down as necessary for establishment of pay and schedule activity items.

C. The Contractor and Engineer shall meet and jointly review the detailed schedule of values within 35 calendar days from the date of the Notice to Proceed. The value allocations and extent of detail shall be reviewed to determine any necessary adjustments to the values and to determine if sufficient detail has been proposed to provide cost loading of the CPM schedule activities. The Contractor shall make any adjustments deemed necessary to the value allocation or level of detail and submit a revised detailed schedule of values within 10 calendar days from the date of the review meeting.

D. Following acceptance of the detailed schedule of values, incorporate the values into the cost loading portion of the CPM schedule. The CPM activities and logic shall have been developed concurrently with development of the detailed schedule of values; however, it shall be necessary to adjust the detailed schedule of values to correlate to individual schedule activities. It is anticipated that instances will occur, due to the independent but simultaneous development of the schedule of values and the CPM schedule activities, where interfacing these two documents will require changes to each document. Schedule activities may need to be added to accommodate the detail of the schedule of values. Schedule of value items may need to be added to accommodate the detail of the CPM schedule activities. Where such instances arise, the Contractor shall propose changes to the schedule of values and to the CPM schedule activities to satisfy the CPM schedule cost loading requirements.

1.12. INCORPORATION OF SCHEDULE OF VALUES INTO CPM SCHEDULE

A. In conjunction with each submittal of the construction schedule, the Contractor shall submit a cash flow projection indicating estimated earnings by month during the entire Contract period and a schedule of values of the Work using the "Schedule of Values" described above, including accepted quantities and prices. The aggregate of these extended prices shall equal the Contract price. Costs shall include all materials, labor, equipment, and appurtenant items necessary to accomplish the Work in accordance with the Contract documents. This schedule shall be satisfactory in form and substance to the Engineer and shall subdivide the Work into the specified component parts. Upon review by the Engineer, the Contractor shall incorporate the schedule into the form for Application for Payment. Maine DMR reserves the right to delete (or add) items of Work from the Contract and the total Contract amount shall be reduced (or increased) by the total amount shown in the schedule of values.

B. The Contractor shall develop the schedule of values (including lump-sum price breakdown) and incorporate into the cost loading function of the CPM schedule. Determine monthly progress payment amounts from the monthly progress updates of the CPM schedule activities. Develop the schedule of values independent but simultaneous with the development of the CPM schedule activities and logic.

C. The Contractor is required to support Maine DMR’s request for monthly project accounting updates. This includes:

1. A forecast of monthly billing cash flow for the project to be provided to Maine DMR’s Project Manager within a week of receipt of order.

2. End of the month project accrual estimates for total charges for that month, year-to-date total and remainder of the month.

1.13. CROSS-REFERENCE LISTING

A. To assist in the correlation of the schedule of values and the CPM schedule, the Contractor shall provide a cross-reference listing, furnished in two parts. The first part shall list each scheduled activity with the breakdown of the respective valued items making up the total cost of the activity. The second part shall list the valued item with the respective scheduled activity or activities that make up the total cost indicated. In the case where a number of schedule items make up the total cost for a valued item (shown in the schedule of values), the total cost for each scheduled item shall be indicated.

B. Update and submit these listings in conjunction with each CPM monthly submittal.

C. Incorporate executed change orders reflected in the CPM schedule into the schedule of values as a single unit identified by the change order number.

1.14. CHANGES TO SCHEDULE OF VALUES

A. Changes to the CPM schedule which add activities not included in the original schedule but are included in the original Work (schedule omissions) shall have values assigned as reviewed by the Engineer. Other activity values shall be reduced to provide equal value adjustment increases for added activities as approved by the Engineer.

B. 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.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 33 00

SUBMITTALS

PART 1 - GENERAL

1.01. DESCRIPTION

A. General

1. This Section specifies the general method and requirements of submissions applicable to the project Work-related submittals.

2. All submittals for this Project will be processed electronically through the Contractor's project manager or project engineer and Maine DMR/Engineer's project manager.

3. Contractor and Engineer to determine agreed upon electronic delivery and tracking mechanism at the Pre-Construction Meeting.

B. Shop Drawings

1. If the Contractor submits reproductions of Contract Drawings and makes no changes or amplifications on them, such submittals will not be considered shop drawings and will be returned without a shop drawing review. If the Contractor uses Contract Drawings as backgrounds and adds details and amplifications, such a submittal will be reviewed as a shop drawing.

2. The use of Contract Drawing reproductions for shop drawings is subject to rejection if sufficient detail is not incorporated to suffice for item-specific shop drawings.

3. Submit electronic copies of shop drawings. The Contractor will process and distribute shop drawings, materials information, and manufacturing data to Project participants. Clearly indicate the Specification Section and/or Drawing number to which each submittal is referenced.

4. If the Contractor submits shop drawings, materials information, or manufacturing data by manufacturers other than those listed in the Specifications, provide the following information with the submittal:

a. The name and address of at least three companies or agencies that are currently using the equipment or product.

b. The name and telephone number of at least one person at each of the above companies or agencies whom Maine DMR/Engineer may contact.

c. A description of the equipment or product that was installed at the above locations. The description shall be of sufficient detail to allow Maine DMR/Engineer to compare it with the equipment or product that is proposed to be installed in this Project.

d. A detailed explanation of how Maine DMR may benefit from the use of the submitted alternate equipment or product.

5. For materials originating outside of the United States for which tests are required, provide recertification and retesting by an independent domestic testing laboratory.

C. Other Submittals

1. The Contractor shall submit evidence of compliance with all applicable requirements of 29 CFR 1926.1437(k) through (n) if execution of the Work will be supported by floating crane(s) or land crane(s) on barge(s). Where required under 1926.1437(m) or 1926.1437(n), the report and supporting calculations demonstrating barge stability under all controlling load configurations must be sealed by a registered professional engineer.

D. Submittal Log

1. The Contractor and Maine DMR/Engineer shall exchange Submittal Logs on a regular basis, e.g., biweekly. The Submittal Log shall be on a digital file in a format acceptable to Maine DMR/Engineer. At a minimum, the Submittal Log shall include:

a. A Submittal title and description.

b. The resubmittal number, if applicable.

c. The Specification Section Number.

d. The date submitted.

e. The date returned.

E. Submittal Requirements

1. Submittals shall be in accordance with this Section and subsequent Sections.

2. Contractor shall submit, at the Pre-Construction Meeting, a schedule describing the sequence of submittals, the manufacturer, and the delivery of equipment.

3. Make submittals promptly in such sequence as to cause no delay in the Work. Schedule submission a minimum of 21 calendar days before reviewed submittals will be needed.

4. The Contractor shall initiate transmission of Submittals to Maine DMR/Engineer soon after the Notice of Award is issued.

5. Maine DMR/Engineer will return original and second submittals within 21 calendar days of receipt, but Maine DMR/Engineer reserve the right to additional review time for complex submittals such as those containing design calculations. Subsequent submittals will be returned within 10 calendar days of receipt.

6. Submittals shall contain:

    a. The Project title and number.

    b. The date of submission and the dates of any previous submissions.

    c. Contract identification.

    d. The names of:

        (1) Contractor.

        (2) Supplier.

        (3) Manufacturer.

        (4) Identification of the product, with the Specification Section number.

        (5) A letter from each supplier stating that the equipment meets the requirements if the Specifications state any exceptions.

        (6) Field dimensions, clearly identified as such.

        (7) Relationship to adjacent or critical features of the Work or materials.

        (8) Identification of deviations from Contract Documents.

        (9) Identification of revisions on resubmittals.

        (10) Contractor's stamp, initialed or signed, shall certify Contractor's review of submittal, verification of products, field measurements, field construction criteria, and coordination of the information within

the submittal that the product meets the requirements of the Work and of the contract documents.

F. Submittal Format

1. Each submittal shall have a transmittal form, which will be the cover sheet for each submittal. Every page in a submittal shall be numbered in sequence. Submittals shall be electronic in PDF format.

2. Where product data from a manufacturer is submitted, clearly mark which model is proposed, with all pertinent data, capacities, dimensions, clearances, diagrams, controls, connections, anchorage, and supports. Present a sufficient level of detail for assessment of compliance with the Contract Documents.

3. Submittals shall be numbered sequentially. The submittal numbers shall be clearly noted on the transmittal form. Original submittals shall be assigned an alphanumeric submittal number followed by a hyphen and the Specification Section to which the submittal pertains. Resubmittals shall bear the number of the alphanumeric system of the original submittal followed by the subsequent letter of the alphabet to represent that it is a subsequent submittal of the original. For example, if Submittal No. 001A-033000 requires a resubmittal, the first resubmittal will bear the designation 001B-033000; the second resubmittal will bear the designation 001C-033000, and so on.

4. Disorganized submittals that do not meet the requirements above will be returned without review as a rejected submittal.

G. Resubmittals

1. Resubmittals (second submissions) will be reviewed and returned in the same review period as for the original submittal.

2. The Contractor is expected to make a complete and acceptable submittal by the second submission of a submittal item.

3. Third and subsequent submissions will be reviewed and returned within 10 days.

H. Submittal Reviews and Responses

1. All Contractor shop-drawing submittals shall be carefully reviewed by an authorized representative of the Contractor, prior to submission to Maine DMR. Contractor shall date, sign, and certify each submittal as being correct and in strict conformance with the Contract.

2. Maine DMR or the Engineer will return each submittal electronically to the Contractor with recommendations and comments, if necessary.

3. If a submittal is returned to the Contractor marked "NO EXCEPTIONS TAKEN," formal revision and resubmission of said submittal will not be required.

4. If a submittal is returned to the Contractor marked "MAKE CORRECTIONS NOTED," formal revision and resubmission of said submittal will not be required unless indicated. The Contractor shall be responsible for making all corrections noted on the submittal.

5. If a submittal is returned to the Contractor marked "REVISE AND RESUBMIT," the Contractor shall revise the submittal and shall resubmit to Maine DMR to comply with the comments. Normally the reasons for such marking will be given, and the Contractor shall be responsible for making necessary changes to the submittal and resubmit for review.

6. If a submittal is returned to the Contractor marked "REJECTED" the CONTRACTOR shall revise said submittal and shall resubmit said revised submittal to Maine DMR.

7. Fabrication of an item may be commenced only after Maine DMR 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 and shall not be taken as the basis of claims for extra work.

8. Maine DMR's review of Contractor shop drawing submittals shall not relieve the Contractor of the sole and entire responsibility for the correctness of details and dimensions. The Contractor shall assume all responsibility and risk for any misfits due to any errors in Contractor submittals. The Contractor shall be responsible for the dimensions and the design of adequate connections and details.

I. Contractor’s Jobsite Drawings

1. Provide and maintain on the jobsite one complete set of all drawings that form a part of the Contract. The complete set of drawings shall be a hard copy set of drawings or a master PDF set of drawings.

2. Immediately after each portion of the Work is completed, indicate all deviations from the original design shown in the Drawings either by additional sketches or redlines thereon. Once a month, or at otherwise appropriate intervals, email a PDF with relevant portions of this record set to Maine DMR/Engineer.

3. Contractor shall make current as-built drawing redlines available to Maine DMR for review as part of the pay application review process for the Project. Pay

application approval for the Project will be contingent upon maintaining record documents through the progress of the Work.

J. Record Documents

1. Refer to Section 01 78 39 Record Documents.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 35 53

SITE SECURITY

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section covers the initiation of site security measures at the site and maintaining the measures throughout the construction period by the Contractor.

1.02. RESPONSIBILITIES

A. Protect Work and existing facilities from unauthorized entry, theft, and vandalism.

B. Initiate security measures at job mobilization including installation of fencing and gates for Contractor's separate entry to the Property Owner's property.

C. Maintain security measures, including security agents at entry points, throughout construction period until either acceptance of work by Maine DMR, or as directed by Maine DMR to terminate security measures at the site.

D. Report all unauthorized access, theft, or vandalism to the Engineer as soon as possible.

E. Coordinate with Maine DMR and the Engineer investigations by law enforcement.

1.03. ENTRY CONTROL

A. Permit entrance of only authorized personnel and vehicles into project site and existing facilities.

B. Authorized persons must have and present proper identification.

C. Maintain a continuous log of workers and visitors and make available to Maine DMR or the Property Owner on request. The Contractor may be required to utilize the Property Owner's electronic sign-in, sign-out platform and must coordinate with Maine DMR and the Property Owner for approval of its proposed log procedure.

D. Coordinate access of Maine DMR's personnel to Project Work Area with Maine DMR.

E. Provide one spare key for each gate installed through Contractor's fencing to the Property Owner for security purposes.

PART 2 - MATERIALS

A. Install chain link fencing, posts, and vehicular and man gates of similar materials and design to the Property Owner’s existing fencing where identified on the Plans.

PART 3 - EXECUTION

A. Coordinate all fencing and gate installation activities with Property Owner including timing, locations of posts, and exact alignment and locations of fencing components.

END OF SECTION

SECTION 01 40 00

QUALITY REQUIREMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section covers Quality Assurance and Quality Control requirements for this Contract.

B. The Contractor is responsible for controlling the quality of Work, including Work of its subcontractors and suppliers and for assuring the quality specified in these Contract Documents is achieved.

C. The Contractor shall bear the cost and responsibility for scheduling all materials testing for quality assurance purposes, as required by various Sections.

D. The Contractor shall be advised that Maine DMR may directly employ a materials testing consultant to perform independent materials testing and verification for quality assurance purposes.

1. The Contractor shall bear no costs nor responsibility for scheduling Maine DMR-provided quality assurance testing.

2. Maine DMR-provided quality assurance testing shall in no way relieve the Contractor of responsibility for providing the type, quantity, and frequency of testing as required by various Sections.

3. The Contractor shall provide all reasonable assistance with respect to access, scheduling and coordination for Maine DMR-provided quality assurance testing.

1.02. SUMMARY

A. Section includes administrative and procedural requirements for quality assurance and quality control.

B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with these Contract Document requirements.

1. Specific quality-assurance and -control requirements for individual construction activities are specified in the Sections that specify those activities.

2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and -control procedures that facilitate compliance with these Contract Document requirements.

3. The Contractor is not limited by the quality assurance and quality control requirements identified in these Contract Documents to provide the product(s) meeting the project requirements.

1.03. TOLERANCES

A. Monitor tolerance control of installed products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. Should manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding with installation.

C. Adjust products to appropriate dimensions; position before securing products in place.

1.04. REFERENCES

A. For products or workmanship specified by association, trades, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified in these Specifications or are required by applicable codes or these Specifications.

B. Conform to reference standard by date of issue current on date of Contract Documents, or date specified in the individual Specification Sections, except where a specific date is established by code.

C. The contractual relationship, duties, and responsibilities of the parties performing work under this Contract and the Engineer shall not be altered from the Contract Documents by mention or inference in any reference document.

1.05. DEFINITIONS

A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with Project Specification requirements.

B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with Project Specification requirements. Services do not include contract enforcement activities performed by Maine DMR or Engineer.

C. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.

D. Qualified Testing Agency: An entity engaged to perform specific tests, inspections, or both and which is certified or licensed to perform the specific tests or inspections in the State of Maine. Testing laboratory shall mean the same as testing agency.

E. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.

1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).

F. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of three previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.06. CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Engineer for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Engineer for a decision before proceeding.

1.07. CONTRACTOR'S QUALITY-CONTROL PLAN

A. Quality-Control Plan, General: Submit quality-control plan within 10 days of Notice of Award and not less than seven days prior to preconstruction conference. Submit in format acceptable to Engineer. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-control responsibilities. Coordinate with Contractor's construction schedule.

B. Submittal Procedure: Describe procedures for ensuring compliance with requirements through review and management of the submittal process. Indicate qualifications of personnel responsible for submittal review.

C. Testing and Inspection: In quality-control plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:

1. Contractor-performed tests and inspections including subcontractor-performed tests and inspections. Include required tests and inspections and Contractor-elected tests and inspections.

D. Continuous Inspection of Workmanship: Describe process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and inspection specified. Indicate types of corrective actions to be required to bring work into compliance with standards of workmanship established by Contract requirements and accepted mockups.

E. Monitoring and Documentation: Maintain testing and inspection reports including log of accepted and rejected results. Include work Engineer has indicated as nonconforming or defective. Indicate corrective actions taken to bring nonconforming work into compliance with requirements. Comply with requirements of authorities having jurisdiction.

1.08. SUBMITTALS, REPORTS, AND DOCUMENTS

A. Submit under provisions of Section 01 33 00.

B. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:

1. Date of issue.
2. Project title and number.
3. Name, address, and telephone number of testing agency.
4. Dates and locations of samples and tests or inspections.
5. Names of individuals making tests and inspections.
6. Description of the Work and test and inspection method.
7. Identification of product and Specification Section.
8. Complete test or inspection data.
9. Test and inspection results and an interpretation of test results.
10. Record of temperature and weather conditions at time of sample taking and testing and inspecting.

11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.

12. Name and signature of laboratory inspector.

13. Recommendations on retesting and reinspecting.

C. Permits, Licenses, and Certificates: For Maine DMR's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.09. MATERIALS AND EQUIPMENT

A. The Contractor shall comply with manufacturer’s printed instructions for furnished materials, regarding all facets of materials and/or equipment movement, storage, installation, testing, startup, and operation. Should circumstances occur where the Contract Documents are more stringent than the manufacturer’s printed instructions, the Contractor shall comply with the Project Specifications. In cases where the manufacturer’s printed instructions are more stringent than the Contract Documents, the Contractor shall advise the Engineer of the disparity and conform to the manufacturer’s printed instructions. In either case, the Contractor is to apply the more stringent specification or recommendation, unless accepted otherwise by the Engineer.

1.10. QUALITY CONTROL

A. Contractor Responsibilities: Tests and inspections not explicitly assigned to Maine DMR are Contractor's responsibility and the costs for such are to be included in the cost of Work. Perform additional quality-control activities required to verify that the Work complies with requirements, whether specified or not.

1. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.

2. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

3. Comply with manufacturers' instructions, including each step in sequence.

4. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

5. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

6. Perform Work by persons qualified to produce required and specified quality.

7. Verify field measurements are as indicated on Shop Drawings or as instructed by manufacturer.

8. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

9. Where services are indicated as Contractor's responsibility, engage a Qualified Testing Agency to perform these quality-control services.

   a. Contractor shall not employ same entity engaged by Maine DMR, unless agreed to in writing by Maine DMR.

10. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspecting will be performed.

11. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.

12. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.

13. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

14. Contractor’s failure to properly schedule and provide testing services and reports may be cause for rejection, removal and/or replacement of materials at Maine DMR’s discretion and solely at Contractor’s expense.

B. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 01 33 00.

C. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in pre-installation conferences, examination of substrates and conditions, verification of materials, observation of Contractor activities, inspection of completed portions of the Work, and submittal of written reports.

D. Retesting/Re-inspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and re-inspecting, for construction that replaced Work that failed to comply with the Contract Documents. Retesting of noncompliant Work shall be the Contractor's responsibility, shall follow the same procedures as the original testing, and be at the Contractor's cost.

E. Qualified Testing Agency Responsibilities: Cooperate with Maine DMR, Engineer, and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.

1. Notify Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.

2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.

3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.

4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.

5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.

6. Do not perform any duties of Contractor.

F. Contractor’s Associated Services: Cooperate with agencies performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:

1. Access to the Work.

2. Incidental labor and facilities necessary to facilitate tests and inspections.

3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.

4. Facilities for storage and field curing of test samples.

5. Delivery of samples to testing agencies.

6. Preliminary design mix proposed for use for material mixes that require control by testing agency.

7. Security and protection for samples and for testing and inspecting equipment at Project site.

G. Contractor Coordination: Coordinate sequence of activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.

1. Schedule times for tests, inspections, obtaining samples, and similar activities.

H. Contractor Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a component of Contractor's quality-control plan. Coordinate and submit concurrently with Contractor's construction schedule. Update as the Work progresses.

1. Distribution: Distribute schedule to Maine DMR, Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. QUALITY CONTROL

A. Quality control is the responsibility of the Contractor, and the Contractor shall maintain control over construction and installation processes to assure compliance with specified requirements.

B. Means and methods of construction and installation processes are the responsibility of the Contractor, and at no time is it the intent of the Engineer to supersede or void that responsibility.

3.02. TEST AND INSPECTION LOG

A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:

1. Date test or inspection was conducted.

2. Description of the Work tested or inspected.

3. Date test or inspection results were transmitted to Engineer.

4. Identification of testing agency or special inspector conducting test or inspection.

B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Engineer's reference during normal working hours.

3.03. REPAIR AND PROTECTION

A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged Work and restore substrates and finishes.

1. Provide materials and comply with installation requirements specified in other Specification sections or matching existing substrates and finishes.

2. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.

B. Protect Work exposed by or for quality-control service activities.

C. Repair and protection are the Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

3.04. TESTING SCHEDULE

A. Refer to the individual Sections for testing schedules and requirements.

END OF SECTION

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SECTION 01 50 00

TEMPORARY FACILITIES

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section covers the requirements for furnishing all materials, equipment, incidentals, and labor for installing, maintaining, and removing temporary facilities required for commencement, prosecution, and completion of the Work under these Specifications.

B. Contractor is responsible for all temporary facilities and will assume no use of the Property Owner’s existing facilities unless authorized in writing by the Property Owner.

1.02. USE CHARGES

A. General: Installation and removal of and use charges for temporary facilities shall be the responsibility of the Contractor. Contractor shall allow other entities to use temporary services and facilities without cost, including Maine DMR, Engineer, testing agencies, and authorities having jurisdiction.

B. Sanitary Facilities

1. The Contractor shall provide adequate sanitary facilities for the use of its employees employed on the Work. Such facilities shall be made available when the first employees arrive on the site of the Work, shall be properly secluded from public observation, and shall be installed and maintained during the progress of the Work in suitable numbers, at such points, and in such manner as may be required.

2. The Contractor shall maintain the sanitary facilities in a satisfactory and sanitary condition at all times and shall enforce their use. The Contractor shall rigorously prohibit the committing of nuisances on the site of the Work, on the lands of the Property Owner, or on adjacent property.

C. Electric Power Service

1. The Contractor shall make all necessary applications and arrangements and pay all fees and charges for electrical energy necessary for the proper completion of the Work and during its entire progress. The Contractor shall provide and pay for all temporary wiring, switches, connections, fuel, and meters.

2. The Contractor shall provide sufficient electric lighting so that all work may be done in a workmanlike manner when there is not sufficient daylight.

3. All Contractor-provided electrical services shall be performed by qualified electricians and as required by the State of Maine.

D. Temporary Heat

1. If temporary heat is required for the protection of the Work, the Contractor shall provide and install suitable heating apparatus, shall provide adequate and proper fuel, and shall maintain heat as required.

2. Temporary heating apparatus shall be installed and operated in such manner that finished Work or Property Owner's property will not be damaged thereby.

3. All heating apparatus shall be installed and maintained by qualified personnel.

4. All fuels shall be used, maintained, protected, and permitted as required by the State of Maine and as coordinated with Woodland Pulp.

1.03. CONSTRUCTION WATER

A. Related Work Specified Elsewhere:

1. 03 30 00: Cast-In-Place Concrete.

B. The Contractor shall coordinate with the Property Owner for construction water.

1.04. DUST CONTROL

A. Perform dust control operations to prevent construction operations from producing dust that causes a nuisance to:

1. Persons living nearby or traveling in the vicinity of the Work.

2. Maine DMR's or Property Owner's personnel and staff.

B. Use water or dust preventative to control dust. Dust control measures shall be at the expense of the Contractor. Should complaints be received by the Property Owner or Maine DMR, the Contractor shall immediately adjust dust control measures at no expense to the Property Owner or to Maine DMR.

1.05. FIRE DANGER

A. Minimize fire danger in the vicinity of and adjacent to the construction site. Provide labor and equipment to protect the surrounding property from fire damage resulting from construction operations. All costs arising from fire or the prevention of fire shall be at the expense of the Contractor.

B. Provide fire suppression equipment, such as fire extinguishers, appropriate to respond to the fire hazard presented by the Contractor’s activities and materials.

1.06. CONSTRUCTION FENCING

A. Contractor shall provide temporary construction fencing along Construction Limits and elsewhere as needed or directed in order to clearly delineate areas that can be temporarily impacted by construction activities. Temporary fencing shall be orange safety fence, silt fence, wire fence, or other fencing that provides a stable, durable, visible, and exact delineation of the Construction Limits, has a height that provides proper delineation, and can withstand wind and snow loads.

B. Should Construction Limits currently be bordered by existing fence, no installation of temporary construction fencing will be required. The installation of soil berms as Construction Limit delineation will not be allowed.

C. Contractor shall provide adequate signage on or adjacent to construction or bordering Construction Limits fencing and other relevant travel path locations acceptable to the Engineer, Maine DMR, and the Property Owner to clearly direct personnel, delivery drivers, inspectors, and visitors to their respective check-in, working, and emergency evacuation locations with applicable key contact information on respective signage.

D. Contractor is responsible for all other fencing requirements associated with the Project including those necessary for safety and erosion control as specified in Section 01 57 13. Construction fencing will not be accepted as an alternative to silt fencing required for erosion control.

1.07. ACCESS ROADS AND PARKING AREAS

A. Applicable requirements listed in Maine DOT Standard Specifications, latest edition, shall be met.

B. The Contractor shall communicate to the Engineer, Maine DMR, and the Property Owner its access and parking needs, such as the number of vehicle spaces. The Engineer and the Property Owner will identify the location(s) and dimensions of available access and parking for the Contractor. Should available parking not meet the Contractor's needs, the Contractor shall make other arrangements for Contractor employee and subcontractor parking. Such parking shall be for the sole convenience of the Contractor. The Contractor shall be solely responsible for all vehicles using the identified parking area(s).

C. The Contractor shall maintain all access and parking areas in a safe manner, including removal of snow and maintaining travel ways free of ruts and potholes, and shall promptly repair any deficiencies identified by Maine DMR or Engineer.

1.08. PROJECT CONDITIONS

A. Adverse weather may occur during the course of the Project. During adverse weather and against the possibility thereof, the Contractor shall take all necessary precautions so that the Work may be properly done and satisfactory in all respects. When required, protection shall be provided by use of tarpaulins, wood, and building-paper shelters, or other suitable means.

B. Contractor shall supply its own means of monitoring tailwater level near each cofferdam location to remain apprised of current water level and/or flow conditions. The Property Owner relies on the downstream USGS gage and does not continuously monitor tailwater immediately below the hydroelectric station.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 52 10

TEMPORARY FIELD OFFICE BUILDING

PART 1 - GENERAL

1.01 GENERAL FIELD OFFICE REQUIREMENTS

A. Provide required field office compliant with applicable OSHA requirements, laws, and regulations and in accordance with the following requirements within 21 calendar days after the commencement date stated in the Notice to Proceed. All requirements of this Section apply to Contractor's field office except for services and utilities also provided by the Contractor to the Engineer's field office and for restroom facilities for Engineer and Maine DMR use where indicated.

B. Unless released earlier by Maine DMR in writing, maintain the field office in full operation at the site with all utilities connected and operable until 14 calendar days after the Notice of Completion has been executed or recorded. Remove the field office within 28 calendar days from the Notice of Completion date or upon early release of the field office by Maine DMR and restore the site occupied by the field office to the original or specified condition as indicated.

1.02 BUILDING CONSTRUCTION

A. Provide a trailer or modular separate field office. The field office and its appurtenances or accessories shall remain the property of the Contractor. Remove the field office from the site after completion of the project.

B. The Contractor shall be responsible for providing power to the field office and dedicated restrooms under 1.03C. Power will not be provided by Maine DMR.

C. Provide cylinder lock and key on entrance door(s). Provide one (1) set of spare keys to a designated Woodland Pulp representative for security purposes.

1.03 BUILDING UTILITIES

A. Provide refrigerated air conditioning and heating.

B. Provide electricity for both Contractor's and Engineer's field office buildings. Provide a secure wireless internet infrastructure dedicated for use by occupants of office and by occupants of the adjacent Engineer's office.

C. Provide restroom facilities for Engineer and Maine DMR use with a minimum of two toilets and two wash basins; HVAC system including cooling, heating, ventilation, and lighting; and janitorial/cleaning service retained by the Contractor on a weekly basis.

Maine DMR shall be credited a sum of $50 per week that the janitorial service is not provided. Provide additional restroom facilities for Contractor personnel use, including subcontractors and delivery drivers, compliant with OSHA requirements and all other applicable laws and regulations. The Contractor may be required to provide additional restroom facilities and/or cleaning services at no cost to Maine DMR if supplied facilities are not being maintained or serviced to the satisfaction of Maine DMR or the Property Owner or are otherwise considered inadequate for the quantity of personnel or environmental conditions at the Site at any time.

1.04 BUILDING SERVICES

A. Provide janitorial service with one cleaning per week to each Contractor's and Engineer's office buildings.

B. Pay all costs for electricity and gas service, if applicable, for both Contractor's and Engineer's office buildings. Pay internet installation and monthly cost for both.

1.05 ACCESSORY EQUIPMENT

A. Contractor may elect to provide new or re-used equipment.

B. Provide the following accessory equipment:

1. Conference tables and chairs for all onsite attendees of progress meetings.

2. One desktop multi-function copy machine (or access to copy/scan machine at site in Contractor's facilities). Machine must have ability to print, copy, and scan 11-inch by 17-inch paper. Print/copy/scan functions must also be capable of color rendition. "Black and white only" capability is not acceptable.

3. One wall-mounted erasable white marker board, 4 feet by 4 feet minimum, with three markers each in colors red, green, blue, and black.

4. One wall-mounted corkboard for thumbtacks, 4 feet by 4 feet minimum.

1.06 ELECTRICAL OUTLETS AND LIGHTING

A. Provide warm white fluorescent or LED light fixtures to evenly illuminate the rooms to a minimum of 50 foot-candles. Provide a two-lamp fluorescent or lumen-equivalent or better LED fixture in the rest room facilities. Provide light switch in each room.

B. Provide three duplex 120-volt grounding type outlets in each office and one ground fault circuit interrupter type outlet in the rest room. Provide one duplex outlet for each computer, appliance, and printer/copier/scanner.

1.07 INTERNET SERVICE AND TELEPHONE

A. Contractor shall provide unlimited internet service for Contractor and Engineer consistent use and Maine DMR occasional use. The Engineer will supply its own nearby job trailer and must have either dedicated internet or shared wireless access meeting minimum speeds supplied by Contractor.

B. Field office shall be equipped with secure wireless router.

C. Internet service shall be reliable with minimum upload/download speeds of 10 mbps. It is expected that large electronic files containing drawings, specifications, submittals and photographs will routinely be uploaded and downloaded at the office.

D. The Contractor shall be responsible for providing telephones for their use.

1.08 ONSITE POSTED DOCUMENTATION

A. Contractor shall post and maintain the following emergency documents (laminated) in the field office or other acceptable onsite location. Examples of this documentation will be displayed at the onsite pre-bid meeting.

1. Emergency contact list with phone numbers and titles:

a. Woodland Pulp

(1) Control Center

(2) Project Manager

(3) River Supervisor

(4) Safety/Contract Monitor

(5) Production Technicians

b. Contractor and Subcontractors

(1) Project Manager

(2) Superintendent

(3) Foreman

(4) Safety Specialist

c. City/Town

(1) Fire

(2) Police

(3) State Police

(4) County Sheriff

d. Fire & Emergency Plan

e. Emergency Evacuation Plan

f. Spill Response Plan

g. Guideline for Uncooperative Public

1.09 ONSITE DOCUMENTATION:

A. Contractor shall maintain the following documentation. Examples of this documentation shall be displayed at the onsite pre-bid meeting.

1. Daily Job Safety Plans (JSP).

2. Project Safety Plan.

3. Site Security Plan.

4. Woodland Pulp safety & environmental Handbook for Contractors.

5. Safety observations done by the contractor and/or contractor safety personnel.

6. Completed Safety Work Observations (SWO) with open action items clearly identified.

7. Safety meeting documentation:

a. Topic of discussions

b. Attendees

8. Daily Log:

a. Crew size and any new crew members to the site

b. Orientations completed

c. On site deliveries

d. Visitors

e. Weather

f. Etc.

9. Orientation Log.

10. Contractor training certificates and records:

    a. Equipment operator certifications

    b. Welding certifications

    c. Rigging and signalman certifications

11. Lifting and rigging plans.

12. Hot work permits.

13. Lock Out Tag Out (LOTO) documents.

14. Diving certifications and records:

    a. Diving certifications

    b. CPR

    c. Required training

15. Equipment Inspections/pre-use checklist:

    a. Forklift

    b. Man lift

    c. Lull

    d. Crane

    e. Bucket truck

    f. Pump truck

    g. Each piece of equipment requires each own separate JSP.

16. Inspection forms:

a. Stoplogs

b. Gates

c. Etc.

17. Safety Data Sheets:

    a. Maintain copies of all chemical Safety Data Sheets on site. Cannot be referenced back to an offsite location or main office.

18. Updated project specifications, drawings and schedules. Only one set of drawings is required and shall be bound in a 3-ring binder in a central location accessible to all representatives of the Engineer, Woodland Pulp, and Maine DMR.

19. All other postings which are required by OSHA and the State of Maine regarding safety and labor.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 57 13

TEMPORARY ENVIRONMENTAL MANAGEMENT

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section includes the construction, installation, maintenance, and removal of temporary water quality, erosion and sediment control best management practices (BMPs), as necessary, to control surface water runoff, groundwater seepage, and dewatering system discharges at the construction site to protect the overall Project Site and the river and in compliance with all applicable permits.

B. Furnish all materials and labor to construct, install, maintain and remove water quality, erosion, and sediment control BMPs that are required to prevent waterborne sediments and any other potential contaminants from discharging into the river.

C. Water quality, erosion, and sediment control BMPs shall be maintained during the Contract period and shall be removed at the end of construction.

1.02. REFERENCE STANDARDS

A. Maine Department of Transportation (Maine DOT), *Standard Specifications*.

B. All applicable Project Technical Specifications.

C. Project Drawings.

1.03. SUBMITTALS

A. Provide the following submittals in accordance with Section 01 33 00.

B. At least 14 calendar days prior to beginning of any excavation, stockpiling, or other earthwork, submit a Water Quality, Sediment, and Erosion Control Plan to the Engineer showing the Contractor’s methods for control of surface water runoff and erosion.

C. The plan shall address water quality, sediment, and erosion control as required by Project permits and by applicable Federal, State, and local laws and regulations .

D. In the plan, address at a minimum the following issues:

1. Sequence of construction of BMPs relative to other construction activities.

2. Provisions for limiting sedimentation and/or other water quality effects on the river.

3. Inspection of and repair of BMP measures.

4. Sequence for removal of temporary BMP facilities.

1.04. QUALITY ASSURANCE

A. Comply with local, state and federal governing regulations regarding water quality and disposal of excavated material.

B. Comply with the requirements of the State of Maine.

PART 2 - PRODUCTS

2.01. SILT FENCE

A. Provide silt fence conforming to the following:

1. Equivalent opening size of a U.S. Standard Sieve size of 40 (max.), 70 (min.).

   Mullen Burst Strength = 200 psi

   Grab Strength = 120 lbs (min.)

2. Spun bonded nylon fabric reinforced with polyester netting, or polypropylene fabric with 2" x 4"- 12 Ga. woven wire backing fence.

B. Manufacturers:

1. Propex Silt Stop – Amoco Fabrics Company

2. Mirafi 100k – Celanese

3. Or approved equal.

2.02. VEHICLE TRACKING CONTROL

A. Vehicle tracking control pad shall consist of a minimum nine (9) inch thick layer of rock.

B. Rock shall be Type C aggregate conforming to Section 703.06 of the Maine DOT Standard Specifications.

2.03. MISCELLANEOUS

A. Hay Bale Dikes: May be utilized in combination with Silt Fence barriers. Hay Bales shall be secured in position by two 2"x2" wooden stakes (or metal stakes) per bale.

B. Geotextile Membrane: Mirafi 600x or approved equal.

C. Turbidity Curtain: Cormier Turbidity curtain - AH Harris

D. Lagoon Baffles - Slickbar Products Corp. - Seymour, CT

E. Oil booms: Use proven manufacturers providing products for the intended purpose.

PART 3 - EXECUTION

3.01. GENERAL

A. Install BMPs prior to work involving excavation.

B. The first BMP to be installed on the site shall be construction fence, markers and other approved means of defining the Construction Limits. See Section 01 10 00 Summary of Work.

C. Install BMPs in accordance with the Drawings and the Water Quality, Sediment, and Erosion Control Plan.

D. Accumulated sediment and debris shall be removed weekly from all BMPS or at any time that sediment or construction debris adversely impacts the function of the BMP. The Contractor is responsible for sediment clean up and disposal.

E. BMPs shall be maintained and kept in good functional condition for the duration of the project. Inspect the BMPs weekly and after significant precipitation events and promptly repaired. Maintain records of inspections and maintenance repairs. BMPs shall be removed only after disturbed areas are permanently stabilized.

F. Any BMP which, on the opinion of the Engineer, is not effectively performing its intended functions shall be repaired or replaced as soon as possible.

3.02. INSTALLATION

A. Silt Fence: Install and maintain where required or directed in accordance with manufacturers' recommendations prior to beginning clearing or earthmoving operations.

B. Hay Bale Dikes: Install and maintain where required or directed prior to beginning clearing or earthmoving operations.

C. Sedimentation basins and pumping sumps/basins: Install and maintain prior to dewatering operations.

3.03. VEHICLE TRACKING CONTROL

A. A vehicle tracking control pad shall be located at all access points where vehicles enter/exit the construction site from all paved rights-of-way.

B. Rock shall be reapplied and regraded as necessary to stabilize the entrance/exit and to maintain a consist depth.

C. Sediment tracked onto paved roads shall be removed throughout the day and at the end of the day by shoveling or sweeping. Sediment shall not be washed away.

D. The vehicle tracking control pad shall be maintained such that no mud or other debris are deposited from vehicles leaving the site beyond the tracking pad.

3.04. CONCRETE WASHOUT AREA

A. Do not locate an unlined concrete washout area within 400-feet of any natural drainage pathway or waterbody, or as otherwise restricted by permits. Do not locate within 1,000-feet of any wells or drinking water sources. If site constraints make this infeasible or if highly permeable soils exist on site, the concrete washout must be installed with an impermeable liner (16-mil minimum thickness) or surface storage alternatives using prefabricated concrete washout devices or lined above ground storage area should be used.

B. The concrete washout area shall be installed prior to concrete placement on site.

C. The concrete washout area shall include a flat subsurface pit that is at least eight-feet-square. The slope leading out of the subsurface pit shall be 3:1 or flatter. The pit shall be at least three feet deep.

D. Vehicle tracking pad shall be sloped 2% toward the concrete washout area.

E. Signs shall be placed at the construction entrance, at the concrete washout, and elsewhere as necessary to clearly indicate the location of the concrete washout area.

F. The concrete washout shall be repaired, cleaned, or enlarged as necessary to maintain capacity for concrete waste.

G. Concrete washout water, wasted pieces of concrete and all other debris in the washout structure shall be transported from the jobsite in a water tight container and disposed of properly.

H. The concrete washout shall remain in place until all concrete for the Project is placed.

I. The cleaning of concrete delivery trucks and chutes is restricted to approved concrete washout location on the site.

J. At the completion of the Project, the concrete washout structure shall be completely removed and the site restored to the satisfaction of the Engineer.

3.05. STOCKPILES

A. Locate stockpiles away from all drainage system components.

B. Place sediment control BMPs around the perimeter of the stockpile.

3.06. REMOVAL OF BMP INSTALLATIONS

A. Do not remove BMP facilities without written acceptance from the Engineer.

B. BMP materials shall remain the property of the Contractor and shall be removed from the site.

END OF SECTION

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SECTION 01 65 00

DELIVERY, STORAGE, AND HANDLING

PART 1 - GENERAL

1.01. DESCRIPTION

A. General

1. The Contractor shall be responsible for receiving all deliveries at the Site and will supply adequate signage with directions and contact information for

2. Manufacturers shall store all equipment at the Manufacturer's facility until Maine DMR or Contractor formally request delivery of equipment to the job site as specified in the Contract Documents. Manufacturer costs shall include all costs associated with storage of all equipment over the entire equipment delivery window.

3. Manufacturers shall deliver all equipment specified in the Contract Documents to the job site within the schedule specified. The Contractor will be responsible for unloading and inspecting the equipment shipment at the job site at time of delivery and acceptance by Maine DMR and Contractor.

4. Prior to acceptance of the equipment by the Contractor and Maine DMR, Manufacturers shall inspect the equipment and provide certification that its condition has not been detrimentally affected either by storage, transportation, and initial off loading activities.

5. This Section specifies the general requirements for the delivery, handling, storage, protection, and inspection of equipment required in the construction of the Work. Specific requirements, if any, are specified in the equipment specifications.

B. Transportation And Delivery

1. Manufacturers shall be prepared to deliver equipment to the job site within the calendar days listed in the Contract schedule. Manufacturers shall deliver the equipment to the job site within 10 calendar days after being formally notified by the Contractor, as long as the required delivery days are on or before the days listed in the Contract schedule. As specified in paragraph C of this Section, Manufacturers shall safely store equipment at the manufacturing plant until the equipment is shipped to the job site. Manufacturers shall be responsible for scheduling and coordinating all equipment deliveries to the job site with the Contractor, who may require varying rates of shipment to accommodate the

Contractor’s sequence of construction and on-site storage space constraints. Manufacturers shall formally notify the Contractor, a minimum of 10 calendar days in advance of all shipments to the job site.

2. Manufacturers shall also perform an inspection of the equipment as it arrives at the job site and provide written certification to the Contractor that the condition of the equipment has not been detrimentally affected as a result of storage, transportation, and off loading operations. Manufacturers shall also inspect the shipment with the Contractor to assure that the equipment complies with the shipping manifest (i.e., shipped equipment and quantities are correct and items are undamaged). Manufacturers shall immediately notify the Contractor verbally and in writing of any problems.

3. Manufacturers shall advise the Contractor in writing through the submittal process specified in Section 01 33 00 of any items that are hazardous, flammable, easily damaged, or sensitive to deterioration. Prior to equipment delivery, Manufacturers shall submit material safety data sheets (MSDSs) to the Contractor for all hazardous materials/chemicals (e.g., lubricants, oils, solvents, etc.) scheduled to be delivered to the job site.

4. Manufacturers shall deliver all equipment to the site with written instructions for handling, storing, unpacking, protecting, transporting, and installing.

C. Storage And Protection

1. Manufacturers may be required to store and protect all equipment and products at an off-site storage facility for up to 90 calendar days after the time specified in Contract schedule until the Contractor requests delivery.

    a. Manufacturers shall store and protect equipment and products in accordance with the Manufacturer's instructions, with seals and labels intact and legible. Storage instructions will be reviewed with the Contractor. Instructions shall be carefully followed, and a written record of this shall be kept by the Contractor. Manufacturers shall arrange storage to permit access for inspection.

    b. Manufacturers shall store all materials in a position to prevent accumulations of standing water and to prohibit rusting.

2. Manufacturers shall notify the Contractor in writing through the submittal process specified in Section 01 33 00 if Manufacturer’s equipment and products have more stringent storage and protection requirements than specified above.

3. Prior to the installation of the equipment, Manufacturers shall inspect the equipment and determine that its condition has not been detrimentally affected

by storage and handling by the Contractor. If such a determination reveals damage, the equipment will be judged to be defective and it will be removed and replaced at the Contractor's expense.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

END OF SECTION

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SECTION 01 75 16

EQUIPMENT TESTING AND START-UP

PART 1 - GENERAL

1.01 REQUIREMENTS

A. This Section includes requirements for testing, startup, and commissioning of the equipment installed under this Contract. The Contractor shall also be responsible for the overall system commissioning and coordinate with equipment manufacturers to ensure the entire facility operates properly and meets design intent and performance.

B. Following testing and commissioning of the new equipment, the equipment shall be put into permanent service.

C. The Contractor shall provide all outside services, materials, labor, supplies, test equipment, and other items necessary to perform the testing, startup, and commissioning procedures specified herein.

D. Participants/representatives for the equipment testing, facility startup, and commissioning shall be qualified and authorized to work on the Facility will include:

1. Contractor;

2. Maine DMR;

3. Engineer;

4. Property Owner, Woodland Pulp LLC;

5. Equipment manufacturers for equipment furnished and installed under this Contract for equipment required to be tested as part of the Work of this Section.

1.02 DEFINITIONS

A. Commissioning

1. Commissioning shall be defined as the operation of equipment or unit process systems, facility support equipment, and facility utilities operating in combination with each other to demonstrate equipment or unit process systems are capable of providing fish passage at specified flows and conditions for a sustained period of operation as required by this Section or equipment or unit process systems specifications. Successful Commissioning shall determine that the equipment or unit process systems are ready to begin Performance Testing. Administrative and minimum technical requirements for Commissioning are specified in Article 1.04

of this Section, while additional technical requirements are contained in PART 3 of the pertinent technical specification(s).

B. Facility

1. The entire Woodland Fish Passage project. This includes the fish lift, fish ladder, downstream passage components, and appurtenant structures and systems.

C. Field Quality Control

1. Refers to specified onsite functional and performance testing of equipment.

D. Functional Test

1. A test or tests in the presence of the Engineer and Maine DMR to demonstrate that the installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements specified including, but not limited to, noise, vibration, alignment, speed, proper electrical and mechanical connections, thrust restraint, proper rotation, and initial servicing.

E. Performance Test

1. A test performed in the presence of the Engineer and Maine DMR and after any required functional test has been accepted, to demonstrate and confirm that individual equipment meets the performance requirements specified in individual Specification Sections.

F. Source Quality Control

1. The term, as used in the individual Specification Sections, which refers to specified testing, performed on specified equipment at the manufacturer's facility prior to shipment.

G. Unit Process

1. As used in this Section, a unit process is a portion of the facility that performs a specific process function, such as gate operators and hoist motors.

1.03 SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Administrative Submittals:

1. Functional and performance test schedules, test plan, procedures, and log format. Submit with Preliminary Progress Schedule.

2. Facility Startup and Performance Evaluation Plan (Plan): Submit with Preliminary Progress Schedule.

C. Quality Control Submittals:

1. Completed Manufacturer's Certificate of Proper Installation as required by individual Specification Sections. Use form provided at the end of this Section.

2. Test Reports: Functional and performance testing, in format acceptable to Engineer.

D. Written documentation, signed by Engineer, of functional and performance test for each piece of equipment tested.

E. Certification of calibration for testing equipment, when so specified.

1.04 COMMISSIONING

A. Commissioning activities for the Facility shall not be initiated until the requirements of Startup are completed for the equipment or unit process systems.

B. The requirements of this Section shall be satisfactorily completed prior to beginning Performance Testing for equipment and unit process systems.

C. Commissioning shall be used by the Contractor and equipment or unit process suppliers to adjust, fine tune, modify and prepare the equipment or system for continuous operation and Performance Testing.

1. Equipment shall not be operated without the guidance and oversight of qualified personnel having the knowledge and experience necessary to conduct proper operation thereof and obtain valid results.

2. All required adjustments, tests, operation checks, and Startup and Commissioning activities shall be provided by qualified personnel.

3. Contractor shall be responsible for planning, supervising, and executing the Startup and Commissioning of the equipment and unit process systems with the assistance of equipment or unit process systems suppliers in accordance with the Plan.

D. The Contractor shall be responsible for commissioning under the direction of its authorized representative.

1. Woodland Pulp’s operating and maintenance staff shall be allowed to observe for the purposes of education and training.

2. Additional witnesses, such as the Engineer, may be present to represent the Maine DMR.

E. For equipment or unit process systems that do not meet Commissioning requirements, it shall be the responsibility of the Contractor and/or equipment or unit process systems suppliers to make the necessary corrections or replacements and repeat Commissioning at no additional cost to Maine DMR.

F. The equipment or unit process systems shall not be Performance Tested or otherwise placed into service until Commissioning is completed as evidenced by a completed Commissioning certificate for the equipment or unit process systems.

G. Commissioning Certificates for each piece of equipment or unit process shall be completed and submitted by the Contractor to the Engineer and Maine DMR for review in accordance with Section 01 33 00.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01 CONTRACTOR'S TESTING AND STARTUP REPRESENTATIVE (FACILITY INTEGRATOR)

A. Designate and furnish one or more Contractor's personnel to coordinate and facilitate testing and facility startup.

B. The Contractor’s testing and startup representative can be an employee of the general contractor or a subcontractor employee. This representative shall be responsible for complete facility integration.

C. Such person or persons shall facilitate, be present, and document facility startup meetings, and shall be available at all times during the testing and the facility startup and performance evaluation period to note any problems and ensure that such problems are corrected as soon as possible, including during night-shift hours if applicable.

D. After two weeks of successful continuous operation of the facility, the Contractor’s startup and testing representative will not be required to be onsite, but shall be available by cell phone to respond in a timely manner to any problem that occurs.

3.02 EQUIPMENT TESTING

A. Preparation:

1. General:

    a. Complete Work associated with each unit and related processes before testing, including all related manufacturer's representative services.

    b. Furnish qualified manufacturer's representatives for Contractor-supplied equipment, when required by individual Specification Sections, to assist in testing.

    c. Obtain from equipment manufacturer's representative the Manufacturer's Certificate of Proper Installation Form, (see Form at end of this Section) when required by individual Specification Sections.

    d. Schedule equipment testing, facility startup, and commissioning meetings to discuss test schedule, plan of test, and required facilities operations interface. Engineer, Maine DMR, and Woodland Pulp must be notified in advance and agree with the schedule.

    e. Provide temporary test equipment and other materials and equipment required to conduct testing.

    f. Provide written documentation, on Contractor's form, of functional and performance test results for each piece of equipment tested. Provide space on form for Engineer's signature that testing is complete.

2. Cleaning and Checking: Prior to beginning functional testing, contractors and their representatives for the parts of their Work included in the testing and facility startup Work of this Section:

    a. Calibrate testing equipment in accordance with manufacturer's instructions and provide calibration certificates.

    b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.

    c. Lubricate equipment in accordance with manufacturer's instructions.

    d. Turn rotating equipment by hand when possible to confirm that equipment is not bound.

    e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.

    f. Check power supply to electric powered equipment for correct voltage and phase orientation – “Bump Test”.

g. Adjust clearances and torque.

h. Test piping for leaks.

3. Ready-to-test determination will be by Engineer based on the following as a minimum:

a. Notification by Contractor of equipment readiness for testing.

b. Acceptable testing plan.

c. Acceptable Operation and Maintenance Manuals.

d. Receipt of Manufacturer's Certificate of Proper Installation.

e. Adequate completion of Work adjacent to, or interfacing with, equipment to be tested, including items to be furnished by Maine DMR, if any.

f. Availability and acceptability of manufacturers' representatives to assist in testing of respective equipment.

g. Satisfactory fulfillment of other specified manufacturers' responsibilities.

h. Equipment and electrical tagging complete.

i. Delivery of all spare parts and special tools.

B. Functional Testing:

1. Conduct as specified in individual Specification Sections.

2. Notify Maine DMR, Engineer, Woodland Pulp, and manufacturer's representatives, in writing, at least 21 days prior to scheduled date of testing.

3. If, in the Engineer's opinion, equipment meets the functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by the individual Specification Sections.

C. Performance Testing:

1. Conduct as specified in individual Specification Sections.

2. Notify Maine DMR, Engineer, Woodland Pulp, and manufacturer's representatives, in writing, at least 21 days prior to scheduled date of testing.

3. Performance testing shall not commence until the equipment is approved by Engineer as having satisfied the functional test requirements specified.

4. Coordinate with Woodland Pulp to shut down existing equipment during startup of new equipment.

5. Follow approved testing plan and detailed procedures.

6. Unless otherwise indicated, furnish all labor, materials, and supplies for conducting the test and performance measurements.

7. Prepare performance test report summarizing test method and results.

8. If, in Engineer's opinion, equipment meets the performance requirements specified, such equipment will be accepted for the purposes of advancing to the facility startup and performance evaluation phase.

3.03 FACILITY STARTUP AND PERFORMANCE EVALUATION

A. General:

1. Support and accommodate Maine DMR and Woodland Pulp's operation and maintenance personnel throughout the Facility Startup and Performance Evaluation Period.

2. All equipment shall be accepted by Engineer as having met the requirements of specified functional and performance testing prior to facility startup.

3. Sequence each unit process to the point that the complete facility is operational for evaluation of unit process and facility performance.

4. Demonstrate proper operation of required interfaces within and between individual unit processes to the Engineer's satisfaction.

5. Provide subcontractor and equipment manufacturer’s staff for Contractor-furnished equipment adequate to perform facility startup, including all components.

6. Schedule ongoing Work so as not to interfere with or delay the completion of facility startup.

7. After the facility is operating, complete performance testing of those items of equipment not previously tested.

8. During the startup period, operate the Work, instruct Maine DMR or Woodland Pulp’s designated operating and maintenance personnel in the function and operation of the Work. Acceptability of the Work’s performance will be based on the simulated operating conditions and providing fish passage as defined in the Contract Documents. The intent of the startup testing is for the Contractor to

demonstrate to Maine DMR, Woodland Pulp, and the Engineer that the Work will function as a complete and operable system under normal as well as emergency operating conditions and is ready for acceptance.

B. Facility Startup and Performance Evaluation Plan:

1. Develop a plan in conjunction with Engineer and Woodland Pulp's operation and maintenance personnel detailing step-by-step instructions for startup of each unit process and the complete facility.

2. Include a method of evaluation and overall performance report for each unit process.

3. Include length of time needed for startup of each unit process and the complete facility.

4. Plan shall consist of bound copies of Startup and Performance Evaluation Forms. Use one form for each unit process; use example form attached, or one of Contractor's design subject to Engineer’s approval.

5. Startup and Performance Evaluation Form will minimally include the following:

   a. Description of unit process being started/operated.

   b. All equipment and devices included in the unit process.

   c. Unit process startup procedures, e.g., valves to be open/closed, order of equipment startup, etc.

   d. Requirements for water, power, etc. needed for startup.

   e. Contractor Certification that each unit process is capable of performing its intended function(s), including fully automatic operation.

   f. Space for evaluation comments.

C. Property Owner and Maine DMR Responsibilities:

1. Provide any startup or performance criteria available to the Contractor, including any functional tolerances or ranges of unit system startup and testing, and its manufacturer’s representatives for their development of the plan. Review the draft plan submitted by the Contractor and provide acceptance of the final plan. Witness operation of process units and devices by the Contractor.

D. Startup Period:

1. Where incremental startup is required, sequencing of unit processes shall be as chosen by the Contractor and submitted to the Engineer and Woodland Pulp for review and comment.

2. Make adjustments, repairs, and corrections necessary to complete facility startup.

3. Incremental startup of individual unit processes shall be considered complete when, in the opinion of the Engineer and Woodland Pulp, the unit process or designated portion has operated in the manner intended for one continuous week (seven consecutive calendar days) without significant interruption, unless time period is specifically changed by the Engineer. This period is in addition to any training, functional, or performance test periods specified elsewhere.

4. In addition to any incremental startup of individual unit processes, the Contractor shall demonstrate to the Engineer that the entire facility operates in the manner intended for one continuous week (seven consecutive calendar days) without significant interruption. This period is in addition to any incremental individual unit process startup periods and any training, functional, or performance test periods specified elsewhere.

5. Significant Interruption:

   a. May include any of the following events:

      (1) Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.

      (2) Failure to meet specified performance for more than two consecutive hours.

      (3) Failure of any critical equipment or unit process that is not satisfactorily corrected within five hours after failure.

      (4) Failure of any noncritical equipment or unit process that is not satisfactorily corrected within eight hours after failure.

      (5) Consistent or repeated failure of specified performance, critical equipment or unit process, and/or noncritical equipment or unit process. Consistent or repeated failure is defined as more than three occurrences, as may be determined by Engineer.

   b. A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.

E. Facility Performance Evaluation:

1. During the Startup Period, conduct a performance evaluation for the purpose of evaluating the full capabilities of the facility and the performance of the computer system until all unit processes are operable including computer system monitoring and control functions.

2. Certify, on the Facility Performance Evaluation Form, that each unit process is capable of performing its intended function(s), including fully automatic and manual operation.

3. Field training of Woodland Pulp's personnel shall be scheduled by the Contractor following Engineer and Woodland Pulp approved Facility Performance Evaluation.

3.04 COMMISSIONING

A. Provide 10 days written notice to the Engineer so that the Engineer may witness each commissioning procedure. The Engineer may witness the performance of any or all commissioning procedures, at the option of the Engineer. The presence or absence of the Engineer at any commissioning test does not absolve the Contractor of performing such test(s) and recording all required information as identified in this specification.

B. Commissioning shall begin at the conclusion of Startup Testing, wherein the equipment or unit process systems are subjected to full operation.

1. On successful completion of Startup, river raw water shall be used for commissioning the equipment and unit process systems to show the equipment and unit process systems function properly. Commissioning shall confirm the proper operation of the equipment and unit process systems with raw water, adjustments shall be made, and the equipment or unit process systems shall be optimized and brought into compliance with fish passage design criteria.

2. The various vendors, equipment suppliers and manufacturers shall provide on-site supervision and assistance for Commissioning services for the facility.

C. The Contractor shall coordinate all Commissioning activities for equipment and unit process systems in accordance with the accepted Plan. The Contractor shall develop a detailed Commissioning plan as part of the accepted Plan that includes the following as a minimum:

1. Description of the overall, general Commissioning process.

2. List of equipment and unit process systems included for Commissioning activities.

3. Detailed Commissioning sequence of activities.

4. Listing of staff and responsibilities for activities.

5. Acceptable function and performance criteria and thresholds.

D. Commissioning Requirements: The following are minimum requirements for completion of Commissioning activities:

1. Commissioning shall show that the equipment and unit process systems are capable of continuous operation using river raw water and utilities; and that the flows, operating parameters and performance requirements for fish passage have been demonstrated for a minimum of seven days of continuous operation, or the period required in the equipment specifications, whichever is longer.

2. Shutdowns that occur because of power outages, acts of God, failure of support systems not part of this contract will not be a cause of failure of the seven days of continuous operation as long as the Facility can resume operation after the shutdown event.

3. If the commissioning fails, the contractor will be responsible for redoing the commissioning at no additional costs to Maine DMR.

E. Documentation Requirements:

1. A Commissioning report shall be prepared and submitted to the Engineer and Maine DMR for review and return with any exceptions noted. The report shall include the following:

a. Contractor Review Comments and Approval Page. This page shall include Certification by the preparer that he/she is the person responsible for the test data and the data is authentic and accurate. This page shall include a listing and signature of all wittiness's to the test. Certification by the Contractor that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Performance Testing.

b. Equipment Suppliers Review Comments and Approval Page. This page shall include Certification by the equipment or unit process systems suppliers that the equipment or unit process systems have been commissioned properly and operated within the design parameters. Certification by the equipment or unit process systems supplier that the equipment or the unit process systems were operated continuously for the specified period and that the equipment or unit process systems operated in compliance with the specified operating conditions, parameters and performance; and that the equipment or unit process systems are suitable for Performance Testing.

c. Engineer and Maine DMR Review Comments, and Approval Page.

d. The Process and Equipment involved in this commissioning test.

e. Commissioning Schedule.

f. Test Descriptions/Procedures:

(1) Equipment or unit process systems tested.

(2) Test dates.

(3) Electrical Inspection and Tests

(4) Test results.

(5) Any repairs or corrections required to obtain acceptable test results.

(6) Calibration sheet for instrumentation or devices used for testing but not part of facility installation.

(7) Test procedure references or standards, as applicable.

g. Appendix:

(1) A summary of all data used in the calculations, including source, formulas with all terms defined.

(2) Calculations for all data submitted, fully defined.

(3) Copies of all raw field data sheets.

(4) Production and/or operational data.

(5) Calibration procedures and work sheets for testing equipment.

(6) Copies of calibration records for instrumentation.

3.05 SUPPLEMENTS

A. The supplements listed below, are a part of this Specification:

1. Facility Startup Evaluation Form.

2. Manufacturer’s Certificate of Proper Installation.

FACILITY STARTUP EVALUATION FORM **DATE:__________________**
WOODLAND PULP **WOODLAND – FISH PASSAGE PROJECT**
SYSTEM TO EVALUATE:
UNIT PROCESSES: (List the unit processes, Number & Description, to be evaluated for this system.)
EQUIPMENT: (List the equipment, Number & Description, to be evaluated for this system.)
OWNER RESPONSIBILITIES: (List the utilities, services, equipment, etc., required by this system that is to be provided by Maine DMR or the Property Owner.)
STARTUP PROCEDURES: (Briefly describe the procedures for the sequential startup and evaluation of this system.)
EVALUATION COMMENTS:

Startup Evaluation	By	Date	Maine DMR Acceptance
Performed:			By:
Witnessed:			Date:

MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION WOODLAND PULP WOODLAND – FISH PASSAGE PROJECT	
Engineer: Verdantas, LLC	Equipment Serial No:_
Equipment Tag No:___	Equipment/System:__
Project No: _____	Specifications Section:______
I hereby certify that the above-referenced equipment/system has been: (Check Applicable) ☐ Installed in accordance with Manufacturer's recommendations. ☐ Inspected, checked, and adjusted. ☐ Serviced with proper initial lubricants. ☐ Electrical and mechanical connections meet quality and safety standards. ☐ All applicable safety equipment has been properly installed. ☐ System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)	
Comments:___ ______ ______	
I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate its equipment and (iii) authorized to make recommendations required to assure that the equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.	
Date:_, 20	
Manufacturer:______________________________ By Manufacturer's Authorized Representative: ______________________ (Authorized Signature)	

END OF SECTION

SECTION 01 77 00

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01. DESCRIPTION

A. Contract closeout is defined to include general requirements near the end of Contract time in preparation for final acceptance, final payment, normal termination of Contract, and similar actions evidencing completion of the Work.

B. Time of closeout is directly related to “Final Completion” of the Contract as defined in the Agreement.

1.02. REQUIREMENTS FOR FINAL PAYMENT

A. Unless otherwise required elsewhere by these Contract Documents, the following shall be furnished by the Contractor prior to application for final payment:

1. Field Services.

2. Installation instructions and Operation and Maintenance manuals, where applicable.

3. Warranties/Guarantees.

4. Certifications of compliance.

5. Record document submittals.

6. Other documents as required by the Contract Documents.

7. Training as required by the Contract Documents.

8. Spare parts and tools.

9. Complete functional, performance, and Commissioning test reports.

1.03. PROJECT RECORD DOCUMENTS

A. Refer to Section 01 78 39.

1.04. WARRANTIES

A. Provide warranties for all equipment specified and depicted herein. The Manufacturer's warranty period shall be a minimum of one year unless otherwise specified and shall commence at the time of Substantial Completion.

B. All warranties shall be assignable to Woodland Pulp.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 78 39

RECORD DOCUMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section describes the requirements related to maintaining and submitting Record Documents.

1.02. DOCUMENTS

A. Maintain at least one set of the following Record Documents, record revisions to the Work as the Work progresses:

1. Construction Drawings.

2. Specifications.

3. Documents and samples called for in the Contract Documents.

4. Reviewed submittals (shop drawings and product data).

5. Approved work plans and permits.

6. Addenda, RFIs, and Change Orders.

7. Field and laboratory test records.

8. Certificates of compliance.

1.03. MAINTENANCE OF DOCUMENTS AND SAMPLES

A. Store Record Documents at Project Site and apart from documents used for construction.

B. File documents and samples in accordance with the Specification Section numbers.

C. Maintain documents and samples in a clean, dry, legible condition and in good order. Do not use Record Documents for construction purposes.

1.04. RECORDING

A. Label each document “PROJECT RECORD” in neat, large printed letters.

B. Record information concurrently with construction progress.

C. Do not cover Work until required information is recorded.

D. Marking (Redlining) of Project Record Documents:

1. Legible and with a red pen or pencil.

2. Ink shall not be water based or subject to easy smearing.

3. PDF redlines are an acceptable alternative to hard copy and must be posted in a shared location, such as SharePoint. Contractor shall maintain the bound print set required in its temporary office during construction per Section 01 52 10 and replace redlined pages no less than monthly, if applicable, in advance of construction meetings.

E. Mark (Redline) Drawings to Record Actual Construction:

1. Field dimensions, elevations, and details.

2. Changes made by Addenda, RFI, or Modification.

3. Details not on original drawings.

4. Horizontal and vertical locations of underground utilities and appurtenances, referenced to a minimum of two permanent surface improvements.

5. Depths and elevations of various elements of foundation and inverts in relation to Project datum.

6. Location of internal utilities and appurtenances concealed in the construction, referenced from visible and accessible features of the structure.

7. All measurements must be as-built and made by a registered surveyor in the State of Maine.

8. Contractor shall make current as-built drawing redlines available to Maine DMR and Engineer for review as part of the pay application review process for the Project.

9. All as-built drawing redlines must be submitted to, and accepted by, Maine DMR and Engineer prior to issuing Final Acceptance.

1.05. SUBMISSION

A. Accompany each submittal with a transmittal letter in duplicate containing:

1. Date, Project Title, and Project Number.

2. Contractor’s name, address, and telephone number.

3. Index containing title and number of each Record Document.

4. Signature of Contractor and Contractor’s authorized representative.

B. Contractor shall make current as-built drawing redlines and Record Documents available as requested by Maine DMR or Engineer to show Record Documents are being maintained through the progress of the Work.

C. Provide input and documentation to support the Engineer in completing the submittal of the as-built drawings and the Final Construction Report.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 01 81 10

SNOW, WIND, AND SEISMIC DESIGN CRITERIA

PART 1 - GENERAL

1.01. SCOPE OF WORK

A. Section Includes: Snow, wind, and seismic design criteria for the following:

1. Pre-engineered electrical enclosures.

2. Other equipment, tanks, and piping located at the Project site and associated with the Work.

B. Related Work Specified Elsewhere:

1. Submittals are included in Section 01 33 00.

2. Electrical items are included in Division 26.

1.02. REFERENCES

All referenced standards shall be the most recently accepted or authorized edition, not withstanding dated editions below.

A. International Code Council (ICC):

1. International Building Code - 2018 Edition.

B. American Society of Civil Engineers (ASCE):

1. ASCE 7, Minimum Design Loads for Buildings and Other Structures - 2016 Edition.

C. American Concrete Institute (ACI):

1. ACI 318, Building Code Requirements for Structural Concrete and Commentary, 2014 Edition.

D. American Institute of Steel Construction (AISC):

1. AISC Steel Construction Manual, 15^{th} Edition.

1.03. GENERAL MINIMUM DESIGN CRITERIA

A. The following general design criteria shall be used in conjunction with the appropriate minimum design criteria sections listed below.

1. Fish Lift Tower and Concrete Structures Building Occupancy Category: II.

2. Electrical Enclosure Building Occupancy Category: II.

3. Other miscellaneous structures Building Occupancy Category: II.

1.04. SNOW LOADING MINIMUM DESIGN CRITERIA

A. Design Requirements: Design in accordance with the requirements of the above referenced codes.

1. Ground Snow Load: 70 pounds per square foot (psf).

2. Exposure Factor: 0.9 (fully exposed).

3. Thermal Factor: 1.0.

4. Importance Factor: 1.0.

5. Refer to Article 1.07, below, for additional design criteria requirements of anchorage to concrete for resistance of snow loads.

1.05. WIND LOADING MINIMUM DESIGN CRITERIA

A. Design Requirements: Design in accordance with the requirements of the above referenced codes.

1. Wind Speed (3 second gust): 107 miles per hour.

2. Wind Exposure: C.

3. Importance Factor: 1.0.

4. Building Occupancy Category: II.

5. Refer to Article 1.07, below, for additional design criteria requirements of anchorage to concrete for resistance of wind loads.

1.06. SEISMIC LOADING MINIMUM DESIGN CRITERIA

A. Design Requirements: Design in accordance with the requirements of the above referenced codes.

1. Short Period MCE (Ss) = 0.238g.

2. Long Period MCE (S1) = 0.068g.

3. Soil Site Class: C.

4. Site Coefficient, Fa = 1.00.

5. Site Coefficient, Fv = 1.00.

6. Site Specific Short Period Spectral Acceleration (SDS) = 0.206g.

7. Site Specific Long Period (1-sec) Spectral Acceleration (SD1) = 0.068g.

8. Component Importance Factor (Ip) = 1.0.

9. Seismic Importance Factor (Ie) = 1.0.

10. Seismic Design Category = B.

11. Selection and application of the appropriate seismic design sections of ASCE 7 shall be the responsibility of the Engineer of Record for the element being designed, however final approval of the selected section of ASCE 7 shall be provided by the Engineer or Maine DMR's Representative.

12. Refer to Article 1.07, below, for additional design criteria requirements of anchorage to concrete for resistance of seismic loads.

1.07. REQUIREMENTS FOR DESIGN OF ANCHORAGE TO CONCRETE

A. Anchorage to concrete shall be in accordance with one of the following methods, unless otherwise approved in writing by the Engineer.

1. Cast-in anchor bolts or headed studs designed in accordance with ACI 318 of the Edition listed above.

2. Post installed adhesive anchors designed in accordance with a current year ICC Evaluation Report for the specific manufacturer's product being used. The ICC Report shall explicitly approve the use of the anchor for resisting the loads that will be applied to it.

B. Seismic forces must be resisted by direct bearing on the anchors used to resist seismic forces. Do not use connections that rely on friction to resist seismic forces.

C. For attachment of items to concrete or metal construction use only anchors, bolts, or other commonly used fasteners that rely on direct bearing or tension developed by properly designed bearing plates for resisting seismic loads.

D. Fasteners shall be designed using only commonly accepted design methodologies, current design codes, and/or ICC Evaluation Service Reports and of materials which are compatible with the materials being fastened.

1.08. SUBMITTALS

A. All submittals shall be in accordance with Section 01 33 00.

B. Refer to other Specifications Sections for additional submittal requirements, however as a minimum, submit anchorage design calculations prepared, signed, and sealed by a Professional Engineer.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

A. The seismic qualification for the items designed under this Specification shall be demonstrated by structural calculations or engineering shake table tests.

B. As required by other Sections of these Specifications, the Contractor shall submit for review and acceptance, test data or structural calculations certified by a Professional Engineer, to show compliance with the requirements of the Contract Documents.

C. Engineering anchorage calculations and figures shall be prepared, stamped, and signed by a Professional Engineer. Calculations shall include the following steps as a minimum:

1. Determination of the operating weight and centroid of the equipment.

2. Determination of the shear and overturning forces at each anchorage due to the force determined, as specified below, being applied at the equipment's centroid.

3. Determination of the shear and tension forces that must be developed by the anchorage at each support to resist the forces calculated.

4. Selection of anchorage details based upon the maximum shear and tension forces calculated above. As a minimum, details shall include number of bolts, materials, diameter, total length, embedded length, required edge distance, and bolt dimensions. The embedded length of bolts shall be suitable to develop the ultimate tensile capacity of the anchorage for ductile failure.

5. The design for cast-in anchor bolts shall be in accordance with ACI 318.

6. The design for post installed anchors shall be in accordance with an ICC Engineering Report, currently approved under the building code listed in Article 1.02, above.

3.02. EQUIPMENT AND COMPONENT ANCHORAGE

A. All equipment and components designed to be fixed in position shall be securely fastened in place in conformance with the anchorage design resulting from the requirements of IBC, ASCE 7, or as specified herein for the Technical Specifications covering a specific piece of equipment under other Divisions.

B. It shall be the responsibility of the equipment and/or component manufacturer/supplier to provide the engineering anchorage calculations and figures to the Contractor for submission to the Engineer. As a minimum, the equipment manufacturer/supplier shall determine the number, dimensions, material, location, embedment, and installation conditions of all anchors used to attach the equipment and/or component to its supporting strata (concrete, steel, aluminum, etc.). At the option of the Contractor, the Contractor or equipment manufacturer/supplier shall furnish the anchors and associated hardware as specified herein and as determined by the manufacturer's/supplier's, Engineer approved, anchorage calculations, for installation by the Contractor.

C. Test data for similar equipment or components may be used, subject to the written approval of the Engineer.

D. All anchorage for equipment and/or components shall, as a minimum, be designed to comply with the requirements of codes referenced in Article 1.02, and as modified below.

E. Anchorage shall be designed to resist the minimum lateral force Fp in the direction of each principal horizontal axis according to the formula in ASCE 7, the design coefficients provided in Article 1.03, above, and with the following parameters:

1. In addition to the lateral force, anchorage shall be designed to resist a vertical force of Fv.

2. Fv = 0.2 x SDS x D, where D is the operating weight of the item who's anchorage is being designed.

3. Anchorage and other supports for equipment and/or components shall be designed to resist lateral forces occurring at each of the three principal directions separately as well as simultaneously. The orthogonal effects shall be combined on a square root of the sum of the squares (SRSS) basis, using 100 percent of the forces in three directions. Where inclusion of vertical loads results in a less conservative design, vertical effects shall be neglected.

4. Anchor bolts, nuts, washers, and bolt sleeves shall be as recommended by the manufacturer of the equipment or assembly, unless stated otherwise in the Contract Documents.

F. For all equipment or components weighing 400-lb or more, the minimum anchor bolt size shall be 5/8-in diameter, and where applicable have 5-in minimum embedment. The minimum anchor bolt size for all other equipment shall be 3/8-in diameter, and where applicable have 4-in minimum embedment. All anchor bolts securing equipment to be grouted shall be furnished with leveling nuts, the faces of which shall be tightened against flat surfaces to not less than 10 percent of the bolt's safe tensile stress.

G. Cast-in-place anchor bolts shall be set before the concrete has been placed and shall be carefully held in position with suitable templates of an acceptable design.

H. No equipment or component shall be anchored to vertical structural elements without written approval of the Engineer, except pipe hangers, supports, or anchorage as specified.

I. In addition to the above requirements, where equipment or components have complex structural systems, (i.e., systems involving components with multiple degrees of freedom and higher order modes of vibration), contains low weight components (e.g., circuit boards, relays, or solenoids), an additional empirical evaluation for such low weight components shall be certified in writing by a Professional Engineer to satisfy the requirements set forth above. At a minimum, such certification shall be based on an empirical evaluation of direct observation of such equipment as part of the factory or shop witness testing including physical "hand" shake and pull tests, and general calculations (if required to verify capacity overload) necessary to satisfy the Engineer of compliance with the above requirements. Certification shall be in the form of a letter from the registered Professional Engineer incorporating the nature of the observations and/or calculations performed including the registered engineer's seal.

3.03. BUILDING AND NON-BUILDING STRUCTURES DESIGN AND ANCHORAGE

A. Building and non-building structures as defined by ASCE 7 shall be designed in accordance with their applicable code requirements.

B. It shall be the responsibility of the building and/or non-building structure manufacturer/supplier to provide the engineering design calculations, detailed framing plans and drawings (including anchorage details) to the Contractor for submission to the Engineer. As a minimum, the manufacturer/supplier shall determine the framing materials to be used; member geometry, layout, and inter connection; anchorage dimensions, material, location, embedment, and installation conditions of all anchors used to attach the building and/or non-building structure to its supporting strata (concrete, masonry, steel, aluminum, etc.). At the option of the Contractor, the

Contractor or equipment manufacturer/supplier shall furnish the anchors and associated hardware as specified herein and as determined by the manufacturer's/supplier's, Engineer approved, anchorage calculations, for installation by the Contractor.

3.04. ABOVEGROUND PIPING

A. Plastic Piping - Plastic piping shall be braced laterally at intervals not exceeding twice that recommended by the manufacturer for vertical support.

B. Other Piping - Piping not included above shall be adequately braced laterally within the guidelines of this Section.

END OF SECTION

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SECTION 01 93 10

INSTALLATION, OPERATION, AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.01 GENERAL

A. Submit three (3) hard copies of all final, approved, manufacturer's operation and maintenance manuals and data pertinent to equipment supplied for the project.

B. Prepare and organize the material in three-ring binders with divider tabs and labels. Include a table of contents.

C. Provide in each hard copy manual an electronic copy of a searchable PDF file including all contents and divider tabs of the manual.

D. Mail one of each hard copy to Maine DMR, the Property Owner, and the Engineer at their respective office location.

E. Submit one electronic copy of all final, approved, manufacturer's operation and maintenance manuals and data pertinent to equipment supplied for the project to Maine DMR, the Property Owner, and the Engineer.

1.02 SUBMITTALS

A. Submittals shall include:

1. List of equipment furnished for project with name, address, and telephone number of each vendor.

2. List of serial numbers of equipment furnished.

3. A copy of shop drawings for mechanical, electrical, and instrument equipment in final form.

4. Manufacturer's operation and maintenance instructions and parts lists.

B. Provide manuals for each piece of equipment including individual components and subsystems of complete assemblies. Line out nonapplicable text and illustrations. The section of the manual on operation shall describe the functions and limitations of each component and its relationship to the system of which it is a part. Where several models, options, or styles are described, the manual shall identify the items actually provided.

C. Each manual shall contain the following:

1. Manufacturer’s contact information for service and local office.

2. Manufacturer's identification, including order number, model, and serial number.

3. Blue line prints or reviewed shop drawings and diagrams of all systems.

4. Certified equipment drawings or reviewed shop drawing data clearly marked for equipment furnished.

5. Complete operating and maintenance instructions for each and every item of equipment, setting forth in detail and step-by-step the procedure for starting, stopping, operating, and maintaining the entire system as installed. Include a schedule of recommended maintenance intervals and tasks.

6. Complete parts list of replaceable parts, their part numbers, and the name and address of their nearest vendor.

7. Any special emergency operating instruction and a list of service organizations (including addresses and telephone numbers) capable of rendering emergency service to the various parts of the system.

8. Copy of manufacturer's equipment guarantees and warranties.

D. Brochures shall be loose leaf with durable plastic or fiberboard covers. Each sheet shall be reinforced to prevent tearing from continued use, and each brochure shall have the following information clearly printed on its cover:

1. Project name, name of contract and property owners, and addresses.

2. Name and address of Maine DMR's Representative.

3. Name and addresses of contractors and subcontractors and department to contact.

4. Telephone number of contractors, including night and emergency numbers.

5. Major equipment vendors' names and telephone numbers.

E. Submit complete manuals at least four weeks before the date of the instructions required by the subsections on "Manufacturer's Services" in the various specification sections.

F. Operation and maintenance manuals specified herein are in addition to any operation, maintenance, or installation instructions required by the Contractor to install, test, and start up equipment.

1.03 EQUIPMENT DATA SHEETS

A. Provide six sets of equipment data sheets, bound in three-ring binders, summarizing the equipment manufacturer's maintenance instructions and recommendations.

B. Two sets of equipment data sheets shall be mailed to each Maine DMR, the Property Owner, and the Engineer each.

C. Submit one electronic copy of all equipment data sheets to Maine DMR, the Property Owner, and the Engineer.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 02 01 20

PROTECTION OF EXISTING UTILITIES

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section includes materials and procedures for protecting existing utilities.

PART 2 - MATERIALS

2.01. REPLACEMENT IN KIND

A. Except as indicated below or as specifically authorized by Woodland Pulp and the Engineer, reconstruct utilities with new material of the same size, type, and quality as that removed. In addition to replacement in kind, Contractor shall address impacts to Woodland Pulp operations.

PART 3 - EXECUTION

3.01. GENERAL

A. Project site is at an operating mill. Coordinate with Woodland Pulp regarding all potential impacts to utilities. No work shall be done near utilities without approval from Woodland Pulp. All excavations or other ground disturbances shall be delineated in sufficient detail for Woodland Pulp and any other agency (Dig Safe, for example) to determine if the area delineated contains any underground utilities or other concerns. No ground disturbance shall occur prior to written notification from Woodland Pulp AND any other affected agency or utility. Coordinate ground disturbance with Woodland Pulp and affected utilities.

B. Replace in kind road improvements, such as curbs and gutters, barricades, fences, signs, etc., that are cut, removed, damaged, or otherwise disturbed by the construction.

C. Where utilities are parallel to or cross the construction but do not conflict with the permanent work to be constructed, follow the procedures given below and as indicated in the Drawings. Notify the utility owner 48 hours in advance of the crossing construction and coordinate the construction schedule with the utility owner's requirements. For utility crossings not shown in the Drawings, notify Woodland Pulp for guidance.

D. Determine the true location and depth of utilities and service connections which may be affected by or affect the work. Determine the type, material, and condition of these utilities. To provide sufficient lead time to resolve unforeseen conflicts, order materials, and take appropriate measures to ensure that there is no delay in work.

E. Expose utilities in advance of the required underground construction.

3.02. PROCEDURES

A. Protect in Place: Protect utilities in place, unless abandoned, and maintain the utility in service, unless otherwise specified in the Drawings or in the specifications.

B. Cut and Plug Ends: Cut abandoned utility lines and plug the ends. Plug storm drains and sewers with a grout plug. Cap waterlines with a cast-iron cap or install a 3-foot-long concrete plug. Dispose of the cut pipe as unsuitable material.

C. Remove and Reconstruct: Where so indicated in the Drawings or as required by the Engineer, remove the utility and, after passage, reconstruct it with new materials. Provide temporary service for the disconnected utility.

3.03. COMPACTION

A. Utilities Protected in Place: Backfill and compact under and around the utility so that no voids are left.

B. Utilities Reconstructed: Prior to replacement of the utility, backfill the trench and compact to an elevation one foot above the top of the ends of the utility. Excavate a cross trench of the proper width for the utility and lay, backfill, and compact.

C. Alternative Construction, Flowable Fill: Flowable fill per Section 03 30 00 may be substituted for other backfill materials to aid in reducing compaction difficulties. Submit specific methods and procedures for the review by the Engineer prior to construction.

3.04. OVERHEAD ELECTRIC

A. Support of overhead electric poles or shielding of overhead electric lines may be required. The Contractor shall make arrangements for and pay all costs for support required or other protections required by the utility.

B. Where shielding of overhead electrical lines is not practical or safe, the Contractor shall employ and enforce safety procedures for maintaining safe work distances from all overhead electric lines.

3.05. BURIED DUCT BANKS

A. If encountered, support buried concrete duct banks and conduits as required by Woodland Pulp. Coordinate these crossings with Woodland Pulp at least four (4) weeks prior to construction.

END OF SECTION

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SECTION 02 41 00

SELECTIVE DEMOLITION

PART 1 - GENERAL

1.01. DESCRIPTION

A. Demolition of the existing fish ladder, piping, and select concrete removal for a portion of the concrete dam to accommodate the construction of the new fish passage structures.

B. Remove and relocate existing equipment, materials, and ancillary features and components to accommodate the construction of the new fish passage structures. Where such components are to be re-used, protect all such components from damage, weather effects, and other conditions which would prohibit re-use.

1.02. REFERENCE DRAWINGS

A. Reference drawings of the existing structures are available for the information of the Contractor. The Contractor shall request any Reference Drawings sufficiently in advance of the Work.

B. No representation or warranty is made by the Maine DMR, Woodland Pulp, the Engineer, or any other party regarding completeness or accuracy of these existing drawings.

C. The Contractor is responsible to obtain, at his own expense, any additional information necessary to construct the Work required under these Specifications.

1.03. SUBMITTALS

A. Submit Demolition Plan.

B. Submit Relocation Plan.

1.04. QUALITY ASSURANCE

A. Demolition Plan:

1. Identify each item to be removed.

2. Provide description of marking items to be demolished, sequence, methods, and equipment used for demolition.

3. Provide a demolition schedule; include coordination/check points with Woodland Pulp.

4. Include containment and disposal measures to prevent debris from entering the river.

5. Identify off-site disposal locations.

6. Describe measures to protect items to be retained and items in proximity to those to be demolished.

B. Relocation Plan:

1. Identify each item to be relocated.

2. Provide description of sequence and methods used for relocated items.

3. Provide a schedule for relocated items; include coordination/check points with Woodland Pulp.

4. Include supporting analysis and calculations for relocating the guy wires that support the utility poles near the substation. Analysis and calculations shall be stamped by a professional engineer.

PART 2 - MATERIALS ((NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

A. Prior to beginning demolition work and concrete removal, coordinate all items of demolition and salvage with Woodland Pulp and the Engineer. Implement all measures to protect items to be retained.

B. Perform demolition and removal work specified herein and indicated in the Drawings in a manner that will not damage parts of the existing structure or systems not intended to be removed. If, in the opinion of Woodland Pulp and the Engineer, the method of demolition used may endanger or damage parts of the existing structure and systems or affect the satisfactory operation of the existing facilities, promptly change the method when so notified by Woodland Pulp and the Engineer.

C. Contractor shall replace in kind all damaged existing facilities not intended to be removed, including concrete and other facilities. The Contractor shall replace damaged items in kind and also address impacts to Woodland Pulp operations.

D. Prepare remaining concrete surfaces to receive new concrete and grout in accordance with Section 03 30 00.

E. Blasting of any kind will not be permitted.

F. Dispose of demolished materials off-site in accordance with applicable laws, ordinances, rules, and regulations. Re-use or recycling are preferred.

G. The Contractor must dispose of demolished materials at their cost and supply documentation as necessary to Woodland Pulp and the Engineer.

3.02. NOISE

A. Noise levels resulting from demolition activities shall comply with all local, state, and federal regulations. Noise producing Contractor activities shall not occur before 7:00 A.M. or after 7:00 P.M. without the written approval of Woodland Pulp and Maine DMR.

3.03. CONTROL OF DUST AND DEBRIS

A. Control dust generated from demolition work. Provide labor, equipment, and materials, and use efficient methods wherever and whenever required to prevent construction operations from producing dust nuisance or damage to persons, property, or activities.

B. Prevent dust control water, pollutants, and debris generated from demolition work from entering the river or Woodland work areas.

3.04. REMOVAL OF EXISTING CONCRETE

A. Remove portions of existing concrete structures within the limits indicated in the Drawings. Do not perform concrete removal beyond limits shown in the Drawings without the written approval from the Engineer.

B. Saw cut concrete along straight lines at the perimeter of the removal areas to the depth shown in the Drawings. Make each cut perpendicular to the concrete surface.

C. Take care to avoid damage to existing concrete to remain in place.

D. After removal of concrete to the specified limits, clean the surface to which new concrete will be bonded to remove dust, debris, and laitance. Perform final cleaning immediately prior to placement of the new concrete.

E. Concrete rubble removed within the limits of the demolition shall be disposed offsite. Do not reuse material from concrete demolition work on this project.

3.05. RELOCATE ANCILLARY FEATURES AND COMPONENTS

A. Remove and relocate the ductwork at the downstream portion of the dam near the new bypass flume. Coordinate the ductwork relocation with Woodland Pulp.

B. Relocate guide wires supporting the utility poles near the substation. Coordinate the guy wire relocation with Woodland Pulp and the Engineer.

C. The Contractor shall identify to Woodland Pulp and the Engineer any other ancillary features or components which it desires or requires to be removed and relocated. Such removal and relocation shall be coordinated with Woodland Pulp.

END OF SECTION

SECTION 03 01 30

CONCRETE REPAIR

PART 1 - GENERAL

1.01. DESCRIPTION

A. Provide materials labor and equipment necessary to repair new concrete construction in coordination with the Engineer. Repairs to new concrete shall be at no additional cost to Maine DMR.

B. Complete repair mortar system installation in accordance with these specifications and the mortar system manufacturer’s instructions regarding surface preparation, application, curing, inspection and requirements for safety.

C. Complete crack repair work in accordance with these specifications and the crack repair material manufacturer’s instructions.

D. Complete joint repair work in accordance with these specifications and the joint repair material manufacturer’s instructions.

E. The location, extent and repair system used for areas of concrete repair shall be coordinated with the Engineer. These include but are not limited to locations where acidic attack of the concrete surfaces has reached a depth of ½” or deeper and at any air voids, bugholes or poorly consolidated concrete areas where the specified filler/surfacer materials cannot be used for filling or surfacing of the concrete.

F. The repair work specified herein is intended to cover the requirements for repair of new concrete only, to a maximum depth of approximately 3-inches. If after surface preparation and cleaning, an area is discovered that requires a repair greater than 3-inches deep, or an area is discovered that requires repair or replacement of reinforcing steel notify the Engineer so that details may be provided to the Contractor for completion of repairs in these locations.

1.02. REFERENCES

A. American Concrete Institute (ACI):

1. 503.4: Standard Specification for Repairing Concrete with Epoxy Mortars.

B. American Society for Testing and Materials (ASTM):

1. C33: Standard Specifications for Concrete Aggregates.

2. C150: Standard Specification for Portland Cement.

3. C321: Standard Test Method for Bond Strength of Chemical-Resistant Mortars.

4. C882: Test Method for Bond Strength of Epoxy Resin Systems.

5. D570: Test Method for Water Absorption of Plastics.

6. D638: Test Method for Tensile Properties of Plastics.

7. D695: Test Method for Compressive Properties of Rigid Plastics.

8. D790: Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

9. D4262: Standard Test Method for pH of Chemically Cleaned or Acid Etched Concrete Surfaces.

10. E337: Standard Practice Test Method for Measuring Humidity with a Psychrometer.

1.03. SUBMITTALS

1. Submit the following in accordance with Section 01 33 00.

2. Repair drawings or photos referenced to redlined drawings showing the areas of planned repair and methods to be employed.

3. Procedures proposed for the accomplishment of repair work. Include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations to be coordinated with other works in progress.

4. Manufacturer’s recommendations and product data sheets for all repair materials including performance criteria, surface preparation, ambient condition requirements and applications, curing requirements, volatile organic compound (VOC) data, and safety requirements.

5. Material Safety Data Sheets (MSDS) for any materials brought on-site including all repair system materials, solvents and abrasive blast media.

6. Design Mixes: Provide concrete and cement mortar in conformance with Section 03 30 00 and as specified herein.

1.04. QUALITY ASSURANCE

A. Furnish the names of all subcontractors proposed for use for this work including necessary evidence and/or experience records to ascertain their qualifications in the application of epoxy, polyurethane, polymer-modified and cement-based compounds.

B. Include in accepted applicator qualifications:

1. A minimum of five years' experience in applying epoxy, polyurethane and polymer-modified and cement-based compounds similar to those specified in this Section.

2. A letter from the manufacturer of the specified materials, on the manufacturer's letterhead, signed by an officer of the company, stating that the subcontractor/applicator has been trained in the proper techniques for the preparation of the surface, and proper methods for mixing, placing, curing, and caring of the manufacturer's products. This letter shall further state that the subcontractor/applicator is on the manufacturer's approved list of contractors.

C. Adhere strictly to the manufacturer's recommendations regarding temperature at time of application for all work. Do not use epoxy materials when either the temperature of the concrete to be repaired or the ambient temperature is below 50 degrees F for a period of 24 hours before, during, or for a period of 48 hours after the completion of the repair. Temporary heat may be used to meet the specified requirements.

D. Use new epoxy, repair materials and use within the shelf life limitations set forth by the manufacturer. Clearly mark the shelf life limitations of each container.

E. The Contractor is ultimately responsible for the concrete repair work. Inspections by the Engineer or others do not limit the Contractor's responsibility.

F. Make all parts of the work accessible for inspections by the Engineer. Correct any conditions not in conformance with the specifications at no additional cost to Maine DMR.

G. Allow changes in the specified repair work methods only with the permission of the Engineer.

H. Provide technical field support or training services required by the accepted material manufacturers at no additional cost to Maine DMR.

I. Provide materials from a single manufacturer for all components of a single repair.

1.05. SERVICES OF MANUFACTURERS REPRESENTATIVES

A. Provide the services of a qualified manufacturer's technical representative to instruct the Contractor's personnel in the mixing, proper use and application of the epoxy, polyurethane, polymer-modified and cement-based compounds.

B. Provide written certification from the manufacturers' representative that materials have been mixed and applied properly and surfaces to receive these products have been prepared properly, all in conformance with manufacturer's requirements.

C. Provide on-site time required for the manufacturer's representative to achieve a successful installation at no additional cost to Maine DMR.

1.06. DELIVERY, STORAGE AND HANDLING

A. Provide shelter to store materials in area or areas designated by Woodland Pulp solely for this purpose. Confine mixing, thinning, clean-up and associated operations and storage of repair mortar materials debris before authorized disposal, to these areas.

B. Mix all specified materials in the sheltered mixing operation and materials from direct sunlight and inclement weather. Protect facilities from staining and damage.

C. Do not dispose of waste materials on-site.

D. Store waste temporarily in closed, nonflammable containers until final disposal. Keep no rubbish in Contractor’s area longer than 24 hours.

E. Deliver all materials to the job site in new, unopened containers. Each container shall bear the manufacturer’s name and label. Labels on all material containers shall contain the following information:

1. Name of product.

2. Federal Specification Number if applicable.

3. Manufacturer’s batch number.

4. Manufacturer’s name.

5. Generic type of material.

6. Hazardous material identification label.

7. Shelf life date.

F. Clearly mark all containers indicating any safety hazards associated with the use of or exposure to the materials.

G. Handle and store materials to prevent damage or loss of label. Protection of materials is the Contractor’s responsibility.

1.07. PROJECT/SITE CONDITIONS

A. Environmental Requirements:

1. Comply with the repair material manufacturer’s recommendations as to environmental conditions under which materials can be applied and cured.

2. Do not apply materials when dust is being generated.

B. Protection:

1. Cover or otherwise protect finish work or other surfaces not being repaired.

C. Ventilation:

1. Provide ventilation to meet product requirements prior to, during, and after application.

PART 2 - PRODUCTS

2.01. WATER

A. The water used for mixing concrete repair products shall be clear, potable and free of deleterious substances.

2.02. AGGREGATE

A. All aggregates shall conform to ASTM C33 and Section 03 30 00.

2.03. EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives, depending on the application. The class of epoxy bonding agent shall be suitable for all ambient and substrate temperatures.

B. Products:

1. Sika Corp.; Sikdur 32.

2. Euclid Chemical Company; Duralcrete.

3. Or acceptable equivalent product.

2.04. ANTI-CORROSION COATING

A. Anti-corrosion coating shall be a three-component, epoxy-modified cementitious material.

B. Products:

1. Sika Corp.; Sika Armatec 110.

2. Sto Concrete Restoration Division; CR 246.

3. Euclid Chemical Company; Duralprep.

4. Or acceptable equivalent product.

2.05. EPOXY CRACK REPAIR BINDER

A. Epoxy crack repair binder shall be a two-component, 100 percent solids, high-modulus, low viscosity epoxy adhesive suitable for crack grouting by injection or gravity feed.

B. Products:

1. Sika Corp.; Sikadur 52.

2. Euclid Chemical Company; Duralcrete LV.

3. BASF Chemical Company; SBC Concresive 1380.

4. Or acceptable equivalent product.

2.06. FLEXIBLE POLYURETHANE CRACK REPAIR MATERIAL

A. Flexible polyurethane crack repair material shall be a one-component, water-activated polyurethane hydrophilic injection grout capable of 700 percent expansion. Polyurethane grout shall form a tough flexible foam seal that is impenetrable to water.

B. Products:

1. Prime Resins; Prime Flex 900 XLV.

2. Avanti International; Scotch Seal 5600 Chemical Grout.

3. Or acceptable equivalent product.

2.07. EPOXY REPAIR MORTAR

A. Epoxy Repair Mortar shall be two-component, 100 percent solids, and 100 percent reactive epoxy resin system.

B. Spall repair mortar for use in horizontal applications.

1. Products:

a. BASF Building Systems; Concresive Paste LPL.

b. Sika Chemical Corp.; Sikadur 22 Lo-Mod.

c. Or acceptable equivalent product.

C. Spall repair mortar for use in vertical and overhead applications.

1. Products:

a. Sika Chemical Corp.; Sikadur 23 Lo-Mod Gel.

b. Or acceptable equivalent product.

2.08. SPALL REPAIRS USING NON-SHRINK CEMENTITOUS MORTAR

A. Products:

1. BASF Building Systems; EMACO S88 CI.

2. BASF Building Systems; Thorite.

3. Sauereisen, Inc.; Underlayment F-120.

4. Or acceptable equivalent product.

2.09. SPALL REPAIRS USING POLYMER MODIFIED CEMENTITOUS MORTAR

A. Repair spalls repair not requiring formwork using a two-component, polymer-modified cementitious mortar having a minimum 28-day compressive strength of 7,000 psi.

B. Spall repair mortar for use in horizontal applications.

1. Products:

a. Sika Corp.; Sikatop 122 Plus.

b. Euclid Chemical Company; Duraltop Fast Set.

c. Or acceptable equivalent product.

C. Spall repair mortar for use in vertical applications.

1. Products:

a. Sika Corp; Sikatop 123 Plus.

b. Euclid Chemical Company; Duraltop Gel.

c. Or acceptable equivalent product.

2.10. SPALL REPAIRS REQUIRING FORMWORK

A. Repair spalls requiring formwork using a two-component, polymer-modified cementitious mortar/pea gravel mixture and shall have a minimum 28-day compressive strength of 6,000 psi. Mix each unit of mortar with Saturated Surface Dry (SSD) pea gravel to form the repair material following the manufacturer's recommendations.

B. Products:

1. Sika Corp.; Sikatop 111 Plus.

2. Euclid Chemical Company; Duraltop Flowable Mortar.

3. Or acceptable equivalent product.

2.11. SEALANT

A. Sealant shall be a two-component polyurethane sealant as specified in Section 03 15 00. Primers and bond breakers shall conform to the sealant manufacturer's recommendations.

2.12. EXPANSION JOINT FILLER

A. Expansion joint filler shall be as specified in Specification 03 15 00.

PART 3 - EXECUTION

3.01. GENERAL REQUIREMENTS

A. Perform exterior work during dry weather and appropriate temperature conditions in accordance with the manufacturer's recommendations. Protect unfinished work during inclement weather with tarpaulins or heavy gage polyethylene sheeting.

B. Coordinate concrete rehabilitation work with other work being performed.

C. Remove scaling, broken, loose and disintegrating materials by use of hand tools or power driven saws, down to solid unyielding material.

D. Clean surfaces thoroughly of efflorescence, oils, grease and other objectionable material in area to be repaired in accordance with the manufacturer's recommendations.

3.02. EPOXY BONDING AGENT

A. Use epoxy bonding agent to adhere fresh mortar to existing concrete. Roughen existing concrete surfaces prior to application of bonding agent. Concrete surface shall be clean and sound, free of all foreign particles and laitance. Place repair material while bonding agent is still tacky or per the written instructions of the manufacturer. Reapply bonding agent if bonding agent cures prior to placement of repair material.

B. Conform to all the requirements of ACI 503.4, and as specified herein.

3.03. ANTI-CORROSION COATING

A. Sandblast, clean and coat reinforcing steel that is cut or exposed during alteration and/or repair operations with an anti-corrosive coating.

B. Cover all exposed parts of the steel with the coating and apply according to manufacturer's recommendations.

3.04. EPOXY CRACK REPAIR

A. Cracks on horizontal surfaces: When permitted by the Engineer, repair existing structural cracks by gravity feeding an epoxy crack repair binder into the prepared crack.

   1. Rout concrete surface at the crack to form a minimum 1/4-inch wide by 1/4-inch deep V-notch and clean to remove all loose and foreign particles. Fill crack with clean, dry sand and pour epoxy crack repair binder into V-notch, completely filling crack.

   2. As binder penetrates into crack, apply additional binder to the V-notch.

B. Cracks on vertical or horizontal surfaces: Repair existing structural cracks by pressure injecting an epoxy crack repair binder into the prepared crack. Seal cracked surfaces and install injection ports per manufacturer's recommendations.

   1. Do not cut reinforcement steel when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and relocate. Patch the abandoned hole immediately with epoxy mortar flush with the surface of the existing concrete.

   2. Once the surface sealing material has cured, inject crack with epoxy crack repair binder as directed by the manufacturer.

   3. Remove injection ports upon satisfactory completion of crack injection and patch with epoxy mortar.

3.05. FLEXIBLE POLYURETHANE CRACK REPAIR

A. Repair leaking cracks by pressure injecting with a waterproof hydrophilic injection grout seal crack surfaces and install injection ports per manufacturer's recommendations.

B. Do not cut rebar when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and patch immediately with epoxy mortar flush with the surface of the existing concrete.

C. Once the surface sealing material has cured, inject crack with waterproof hydrophilic injection grout as directed by the manufacturer.

3.06. SPALL REPAIR

A. Saw cut the perimeter of the repair area to a minimum depth of 1/2-inch below the surface of the concrete. Chip all loose concrete in the repair area to remove loose and degraded concrete to a minimum of 1/2-inch or until a sound substrate is reached. Clean the area and repair to the original dimensions with spall repair patching material according to the manufacturer's recommendations.

B. Make final finished surface of patches flat, level and even with the existing concrete surface. Do not feather repair mortar to meet existing concrete surface.

C. Finish final patches on horizontal surfaces consistent with the finish on the existing structure.

3.07. JOINT REPAIR

A. Remove sealant, bond breaker and joint filler.

B. Remove unsound concrete on the joint faces.

C. Remove laitance and provide a clean dry surface.

D. Prepare an epoxy mortar by combining epoxy crack repair binder with aggregate following the manufacturer's instructions.

E. Restore surface to original dimensions by troweling epoxy mortar onto the existing substrate in a manner to ensure bonding following the manufacturer's instructions.

F. Cure repair in accordance with the manufacturer's instructions.

G. Install new joint filler, bond breaker and sealant.

3.08. CURING

A. Cure repair materials in accordance with manufacturer recommendations.

3.09. CLEANING

A. Mechanically remove excess material from walls, floors, etc. after material has cured.

B. Clean excess materials caused by work under this Section from existing surfaces by the use of power sanders. Sand cracks flush to adjacent surfaces.

C. Remove misplaced sealants using methods and materials recommended by the manufacturers. Leave finished work and work area in a neat and clean condition.

3.10. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 03 10 00

CONCRETE FORMWORK

PART 1 - GENERAL

1.01. DESCRIPTION

A. Provide design and furnish materials for fabricating, erecting and removing formwork, falsework and shoring for cast-in-place concrete and flowable fill as shown on the Contract Drawings and specified herein for a complete installation.

B. Use formwork to cast all cast-in-place concrete structures.

1.02. REFERENCES

A. American Concrete Institute (ACI):

1. 117/117R: Standard Tolerances for Concrete Construction and Materials.

2. 309.2R: Identification and Control of Visible Effects of Consolidation on Formed Concrete Surfaces.

3. 318/318R: Building Code Requirements for Structural Concrete and Commentary.

4. 347: Guide to Formwork for Concrete.

B. American Society of Civil Engineers (ASCE):

1. ASCE 7, Minimum Design Loads for Buildings and other Structures

C. Engineered Wood Association (APA).

D. National Institute of Standards and Technology:

1. Voluntary Product Standard PS 1 Structural Plywood.

1.03. DESIGN REQUIREMENTS

A. Design formwork in conformance with the methodology of ACI 347R for anticipated loads, lateral pressures, depth of concrete placement and rate of concrete placement. Design shall consider any special requirements due to the use of self-consolidating, plasticized and/or retarded set concrete. All forms and shoring shall be designed at the Contractor’s expense.

1.04. QUALIFICATIONS

A. Formwork Designer: Formwork, falsework, and shoring design shall be by a licensed engineer.

1.05. SUBMITTALS

A. Submit product data for form ties, spreaders, chamfer strips, form coatings, and bond breakers.

B. Submit formwork drawings and calculations signed and sealed by a professional civil engineer or structural engineer.

1.06. QUALITY ASSURANCE

A. Design of Formwork

1. The Contractor shall assume responsibility for the design, engineering and construction of formwork. Forms shall be designed to produce concrete members identical in shape, lines and dimensions to members shown on the Contract Documents.

2. When high range water reducer (superplasticizer) is used in concrete mix or when self-consolidated concrete is specified, forms shall be designed for full hydrostatic pressure per ACI 347.

3. The formwork shall be designed for the loads and lateral pressures in accordance with ACI 347 and wind loads of 30 pounds per square foot.

4. Construction and contraction joints, openings, offsets, recesses, chamfers, blocking, screeds, bulkheads, waterstops, anchorages, inserts, and other features shall be provided.

5. Formwork shall be designed to be readily removable without impact, shock, or damage to 'green' concrete surfaces and adjacent materials.

6. The maximum panel deflection shall be 1/360 of the span between structural members.

B. Unless otherwise specified herein, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits as given in ACI 117.

C. Materials, fabrications and workmanship found defective shall be promptly removed and replaced and new acceptable work shall be provided in accordance with Contract requirements at no additional cost to Maine DMR.

1.07. DELIVERY, STORAGE, AND HANDLING

A. Materials shall be delivered to the site in undamaged condition and at such intervals as will avoid delay in the work.

B. Material shall be stored and protected in a clean, properly drained location. Material shall be kept off the ground under a weather-tight covering permitting good air circulation. Formwork materials shall be stored on dry wood sleepers, pallets, platforms or other appropriate supports which have slope for positive drainage. Materials shall be protected from distortion, excessive stress, corrosion and other damage. Materials shall not be stored on the structure in a manner that might cause distortion or damage to the supporting structure.

PART 2 - PRODUCTS

2.01. LUMBER

A. Lumber used in form construction shall be Douglas fir, No. 2 grade, S4S, Standard Grading and Dressing Rules No. 16, West Coast Lumber Inspection Bureau; or Southern Yellow Pine, No. 2, S4S, Standard Grade Rules Southern Pine Inspection Bureau. Boards shall be 6 inches or more in width.

2.02. PLYWOOD

A. Only grade-marked plywood conforming to APA shall be provided.

B. Plywood used in form construction shall be Grade B-B, Class 1 plyform, mill-oiled, and sanded on both sides in conformance with U.S. Product Standard PS 1 Structural Plywood.

C. Thickness shall be sized to maintain alignment and surface smoothness, but not less than 5/8-inch thick.

2.03. STEEL FORMS

A. Commercial grade sheets not less than 16 gage shall be provided.

B. Stock material that is free from warps, bends, kinks, cracks, and rust or other matter that could stain the concrete shall be provided.

2.04. FORM MATERIAL LOCATIONS

A. Wall Forms

1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particleboard, or steel in new and undamaged condition, of sufficient strength and surface smoothness to produce specified finish.

B. All Other Forms: Materials as specified for wall forms.

2.05. FORM TIES

A. Locate form ties on exposed surfaces in a uniform pattern. Place form ties so they remain embedded in the concrete except for a removable portion at each end. Form ties shall have conical or spherical type inserts with a maximum diameter of 1 inch. Construct form ties so that no metal is within 1-1/2 inch of the concrete surface when the forms, inserts, and tie ends are removed. Do not use wire ties. Ties shall withstand all pressures and maintain forms within acceptable deflection limits.

B. Flat bar ties for panel forms shall have plastic or rubber inserts having a minimum depth of 1-1/2 inch and sufficient dimensions to permit patching of the tie hole.

C. Tapered form ties shall be tapered through-bolts or through-bolts that utilize a removable tapered sleeve.

D. Wire ties are not permitted.

E. Waterstop for Ties: For water-holding structures, furnish one of the following:

1. Integral steel waterstop 0.103 inch thick and 0.625 inch in diameter tightly and continuously welded to tie.

2. Neoprene waterstop 3/16-inch thick and 15/16 inch diameter whose center hole is one-half diameter of tie, or molded plastic waterstop of comparable size.

F. Elastic Vinyl Plug

1. Design and size of plug shall allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal forming watertight seal.

2. Manufacturer:

a. Dayton Superior, Miamisburg, OH; A58 Sure Plug.

b. Or acceptable equivalent product.

G. Mechanical EPDM Rubber Plug:

1. Mechanical plug for taper tie.

2. Manufacturers:

a. Greenstreak Group Inc.

b. Or acceptable equivalent product.

3. Friction fit plugs will not be allowed.

2.06. BOND BREAKER

A. Bond breaker shall be a V.O.C.-compliant nonstaining type that will provide a positive bond prevention.

B. Manufacturers:

1. Edoco Burke; Clean Lift 90 W.B.

2. Nox-Crete, Inc.; Silcoseal 97EC.

3. Or acceptable equivalent product.

2.07. FORM CAULKING

A. Form caulking shall be a one-component, gun-grade silicone sealant that is capable of producing flush, watertight and non-absorbent surfaces and joints. Sealant shall be compatible with the type of forming material and concrete ingredients used.

B. Products:

1. Series 1200 Construction Caulking; GE Silicones, Waterford, NY.

2. Dow Corning 999-A; Dow Corning Co., Midland, MI.

3. Or acceptable equivalent product.

2.08. CHAMFER STRIPS

A. Provide chamfer strips, of the size required to form the chamfered edge detail shown on the Drawings. Chamfer strips shall be milled from clear, straight-grain pine, surfaced each side, or having extruded vinyl type with or without nailing flange unless otherwise shown on the Contract Documents.

2.09. INSERTS

A. Provide galvanized cast steel or galvanized welded steel inserts, complete with anchors to concrete and fittings such as bolts, wedges and straps.

2.10. FORM RELEASE AGENT

A. Form release agent shall not bond with, stain, or adversely affect concrete surfaces and shall not impair subsequent treatments of concrete surfaces when applied to forms. A ready-to-use water-based material formulated to reduce or eliminate surface imperfections and containing no mineral oil or organic solvents.

B. Manufacturers and Products:

1. BASF, Shakopee, MN; MBT, Rheofinish 211.

2. Cresset Chemical Company; Crete-Lease 20-VOC.

3. Unitex Chemicals; Farm Fresh.

4. Magic Kote: Symons Corporation, Des Plaines, IL.

5. Or acceptable equivalent product.

PART 3 - EXECUTION

3.01. FORM TOLERANCES

A. Comply with the requirements of ACI 117 for tolerances for formed surfaces except as specified in Table 03 10 00-1.

Table 03 10 00-1	
Vertical alignment (plumbness)	1/4-inch in any 10 feet and 1-inch maximum for entire length
Variation in the lines and surfaces of foundation mats, base slabs and walls	1/4-inch in any 10 feet and 1-inch max. for entire length
Variation from the level or from the grades indicated on the Drawings	1/4-inch in any 10 feet
Variation of the linear structure lines from established position in plan	1/2-inch in any 20 feet and 1-inch maximum for entire length
Variation of distance between walls	1/4-inch in any 10 feet and 1-inch maximum for entire length and height
Variation in the sizes and locations of sleeves, floor openings, and wall openings	Minus 1/4-inch.

Table 03 10 00-1	
	Plus 1/2-inch.
Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus 1/4-inch. Plus 1/2-inch.
Offset between adjacent panels of formwork facing material	1/2-inch (ACI 117 Class C finish).
Offset between adjacent panels of formwork facing material for exposed surfaces where appearance is of importance	1/8-inch (ACI 117 Class A finish).

B. Tolerances are not cumulative.

C. Where equipment is to be installed, comply with manufacturer's tolerances if more restrictive than above.

D. Failure of the forms to produce the specified concrete surface and surface tolerance shall be grounds for rejection of the concrete work. Rejected work shall be repaired or replaced at no additional cost to Maine DMR.

3.02. PREPARATION

A. Clean form surfaces to be in contact with concrete or foreign material prior to installation. Tape, gasket, plug, and/or caulk joints, gaps, and apertures in forms so that the joint will remain watertight and withstand placing pressures without bulging outward or creating surface irregularities.

B. Coat form surfaces in contact with concrete with a form release agent prior to form installation.

C. Keep form coatings off steel reinforcement, items to be embedded, and previously placed concrete.

D. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

3.03. ERECTION AND INSTALLATION

A. Forms shall be constructed in accordance with ACI 347 to required dimensions, plumb, straight and mortar tight, and all joints and seams shall be made mortar-tight. Forms shall be substantial, properly braced, and tied together to maintain position and shape and to resist all pressures to which they may be subject. Unless otherwise indicated on the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits in ACI 117 and herein specified.

B. Provide means for holding adjacent edges and ends of form panels tight and in accurate alignment to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Forms shall be tight and shall prevent the loss of mortar and fines during placing and vibration of concrete.

C. Provide one cleanout and inspection opening 12-inches-wide by 18-inches-high, every 7-feet at the bottom of each lift of forms.

D. Provide exterior corners in concrete members with chamfers as specified.

E. Provide means for removing forms without injury to the surface of finished concrete.

F. Do not embed any form-tying device or part thereof other than metal in the concrete.

G. Locate large end of taper tie on the "wet" side of the wall.

H. Use only form or form-tying methods that do not cause spalling of the concrete upon form stripping or tie removal.

I. Form surfaces of concrete members except where placement of the concrete against the ground or rock is shown in the Drawings. The dimensions of concrete members shown in the Drawings apply to formed surfaces, except where otherwise indicated. Placement of concrete against the ground shall be limited to footings. Concrete walls shall be placed against excavated rock where shown in the Drawings.

J. Set anchor bolts and other embedded items accurately before placing concrete and hold securely in position until the concrete is placed and set. Check special castings, channels, or other metal parts that are to be embedded in the concrete prior to and again after placing concrete. Check nailing blocks, plugs, and strips necessary for the attachment of trim, finish, and similar work prior to placing concrete.

3.04. PROTECTION

A. During installation, the forms shall not be used as a storage platform nor as a working platform until the forms have been permanently fastened in position.

3.05. REMOVAL OF FORMS

A. Forms shall be removed in accordance with ACI 347 recommendations without damage to concrete and in a manner to ensure complete safety to the structure.

Forms, form ties and bracing shall not be removed without specific permission of the Engineer.

B. The following table indicates the minimum allowable time after the last cast concrete is placed before forms, shoring, or wall bracing may be removed; during which the air surrounding the concrete is above 50°F.

Table 03 10 00-2	
Sides of footings	24 hours
Walls, vertical sides of beams, columns, and similar members not supporting loads	48 hours
Slabs, beams, and girders	10 days (forms only)
Shoring for slabs, beams, and girders	Until concrete strength reaches 70 percent specified 28-day strength (based on field cylinders) and 7 days minimum
Wall bracing	Until top or roof slab concrete reaches 70 percent specified 28-day strength and 7 days minimum

C. Removal times will be increased if the concrete temperature following placement is permitted to drop below 50 degrees F.

D. Do not remove supports and re-shore.

3.06. PATCHING OF TAPERED TIE HOLES

A. Elastic Vinyl Plugs

1. Clear tie hole of all loose debris with a taper tie void brush and flush debris from tie hole with air or water.

2. Install elastic vinyl plug from larger tie hole end in accordance with manufacturer’s instructions using an insertion tool as recommended by the manufacturer.

3. Coat entire annular surface of the hole with epoxy bonding compound prior to filling with non-shrink, non-metallic patching mortar. Apply epoxy in accordance with manufacturer’s instructions.

4. Fill each side of hole with mortar. Apply mortar to the "wet" side of the wall first. Consolidate mortar solidly into the hole.

B. Mechanical Plugs

1. Clear tie hole of all loose debris with a taper tie void brush and flush debris from tie hole with air or water.

2. Install mechanical plug in accordance with manufactures instructions.

3. Coat entire annular surface of the hole with epoxy bonding compound prior to filling with non-shrink, non-metallic patching mortar. Apply epoxy in accordance with manufacturer’s instructions.

4. Fill each side of hole with mortar. Apply mortar to the "wet" side of the wall first. Consolidate mortar solidly into the hole.

3.07. FIELD QUALITY CONTROL

A. Contractor shall notify the Engineer of readiness for items under this Section to be inspected a minimum of five working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

3.08. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 15 00

CONCRETE JOINTS AND ACCESSORIES

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section describes materials, testing, and installation of concrete joints and accessories as specified and as shown on the Contract Drawings.

1.02. REFERENCES

A. American Society for Testing and Materials (ASTM):

1. A276: Standard Specification for Stainless Steel Bars and Shapes.

2. C920: Specification for Elastomeric Joint Sealants.

3. C1193: Guide for Use of Joint Sealants.

4. D412: Standard Test Methods or Vulcanized Rubber and Thermoplastic Elastomers – Tension.

5. D570: Standard Test Method for Water Absorption of Plastics.

6. D624: Standard Test method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.

7. D638: Standard Test Method for Tensile Properties of Plastics.

8. D746: Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

9. D747: Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.

10. D792: Standard Test Methods for Density and Specific Gravity of Plastics by Displacement.

11. D994: Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

12. D1752: Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

13. D2240: Standard Test Method for Rubber Property – Durometer Hardness.

B. U.S. Army Corps of Engineers:

1. CRD-C 572: Specifications for Polyvinylchloride Waterstop.

1.03. SUBMITTALS

A. Submit following shop drawings in accordance with 01 33 00.

1. Manufacturer's printed data and application instructions for specified materials and locations where materials are to be used.

2. Submit one sample of each type of waterstop.

3. Submit layouts for joints.

4. Certification that materials used within the joint system are compatible with each other.

1.04. QUALITY ASSURANCE

A. Do not add, relocate or omit joints without written permission from the Engineer.

B. Reject material exceeding expiration date for use.

C. Clean concrete surfaces to receive expansion joint compound in accordance with the printed instructions of the joint compound manufacturer.

1.05. DELIVERY, STORAGE AND HANDLING

A. Transport, handle, and deliver materials to the job site in the manufacturer's sealed bags, unopened containers or banded pallets.

B. Store materials off the ground on a platform or skids and protect with covers from snow, rain and ground splatter.

C. Store expansion joint compounds in a dry location where they cannot freeze.

D. Store plastic products and waterstops under cover in a dry location, out of direct sunlight.

1.06. MANUFACTURER'S SERVICES

A. Prior to joint preparation for joints receiving sealant materials, require joint manufacturer's technical representative to demonstrate, on site, joint preparation, priming, and sealant materials application for the Contractor's personnel performing joint work.

PART 2 - PRODUCTS

2.01. PVC WATERSTOP

A. Waterstops shall be extruded from a PVC compound and shall be flat ribbed or ribbed with centerbulb type. Waterstop shall comply with U.S. Army Corps of Engineers Specification CRD-C-572.

B. PVC waterstops for construction joints:

1. Flat ribbed type, 6 inches wide unless otherwise noted on the Contract Drawings, with a minimum thickness of 3/8-inches. Products:

   a. Sika Greenstreak; Model 679.

   b. Or accepted equivalent product.

2. Flat ribbed type, 4 inches wide unless otherwise noted on the Contract Drawings, with a minimum thickness of 3/16-inches. Products:

   a. Sika Greenstreak; Model 781.

   b. Or accepted equivalent product.

3. PVC waterstop for expansion joints shall be ribbed with a center bulb, 9 inches wide with a minimum thickness of 1/4-inches. The center bulb shall have an O.D. not less than 1-3/8 inches. Products:

   a. Sika Greenstreak; Model 696.

   b. Or accepted equivalent product.

4. PVC waterstops for sealing existing concrete structures and new concrete placement shall be retrofit type, 6 inches wide and 3-3/16 inches height with a minimum thickness of 3/8-inches. Attach waterstop to existing concrete using 1/4-inch by 2-1/4 inch stainless steel sleeve expansion bolt with stainless steel batten bars. Products:

   a. Sika Greenstreak; Model 609.

   b. Or accepted equivalent product.

C. Provide waterstops resistant to chemical action with Portland cement, alkalis, acids, and not affected by mildew or fungi. It shall show no effect when immersed for 10 days in a 10 percent solution of sulfuric or hydrochloric acid, saturated lime solution or salt water. Waterstops shall be such that any cross section will be dense, homogeneous, and free from porosity and other imperfections. They shall be symmetrical in shape. When tested in accordance with Federal Standard No. 601, the material shall meet the requirements in Table 03 15 10-1.

TABLE 03 15 10-1	
Requirement	**ASTM Spec.**
Tensile strength, 1,600 psi	D638
Hardness, Shore durometer, 70-80	D2240
Elongation, ultimate, 300 percent to 450 percent	D638
Water absorption, dry weight, maximum (48 hours) 0.15 percent	D570
Specific gravity, 1.3 to 1.4	D792
Stiffness in flexure, 600 psi	D747
Cold brittleness, -35 degrees F	D746
Tear resistance, 300 lbs/inch	D624

2.02. HYDROPHILIC RUBBER WATERSTOP

A. Provide a bentonite free rubber waterstop with adhesive back. Waterstop shall expand by a minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast. Provide minimum concrete cover as recommended by the waterstop manufacturer. Center the waterstop between vertical reinforcement.

1. Products:

a. Adeka; Ultraseal MC-2005T.

b. Or accepted equivalent product.

2.03. HYDROPHILIC CAULK WATERSTOP

A. Provide a water-swelling, single component, elastic sealant. Caulk waterstop shall expand by a minimum of 80 percent of dry volume in the presence of water.

1. Products:

   a. Adeka; Ultraseal P-201.

   b. Or accepted equivalent product.

2.04. JOINT SEALANT FOR CONCRETE STRUCTURES

A. Joint sealant shall be a multipart, gray, nonstaining, nonsagging, gun grade polyurethane sealant, which cures at ambient temperature to a firm, flexible, resilient, tear-resistant rubber. Sealant shall comply with ASTM C920, Type M, Grade P, Class 25 for horizontal joints and Grade NS, Class 25 for vertical joints and be recommended by the manufacturer for continuous immersion in water. Troweling of sealants into joints will not be permitted. Sealant shall meet requirements in Table 03 15 10-2.

TABLE 03 15 10-2	
Characteristic or Parameter	**Technical Requirements**
Pot life	1 to 3 hours
Hardness	25 Shore A, +/- 5
Elongation	500 percent, ASTM D412
Tensile strength	95 psi, ASTM D412
Peel strength on concrete	No adhesion loss at 25 pounds
Temperature service range	-40 to 170 degrees F
Immersion in water	Continuous

B. Products:

1. Sika Corporation; Sikaflex-2c SL (for horizontal joints; Type M, Grade P, Class 25)

2. Sika Corporation; Sikaflex-2c NS (for vertical joints; Grade NS, Class 25).

3. Or accepted equivalent product.

2.05. BACKING ROD FOR EXPANSION JOINTS

A. Provide an extruded closed-cell polyethylene foam rod. The rod shall be 1/4-inch larger in diameter than the joint width. Where possible, provide full-length sections for the joint; minimize splices:

1. Industrial Systems Department; Minicel backer rod.

2. Hercules, Inc.; Plastic Products Group.

2.06. BOND BREAKER TAPE

A. Provide an adhesive-backed glazed butyl or polyethylene tape that will adhere to the premolded joint material or concrete surface. The tape shall be the same width as the joint. The tape shall be compatible with the sealant.

2.07. PREMOLDED JOINT FILLER FOR BELOW GRADE

A. Joint filler shall be preformed, nonextruded type constructed of closed-cell neoprene conforming to ASTM D1752, Type I.

B. Bituminous-type preformed expansion joint filler conforming to ASTM D994.

2.08. PREMOLDED JOINT FILLER FOR EXPOSED ABOVE GRADE

A. Self-expanding cork per ASTM D1752, Type III.

B. Sponge rubber per ASTM 1752, Type I. Preformed, non-extruded type constructed of closed-cell neoprene.

2.09. EXPANSION JOINT DOWELS

A. Stainless steel smooth bar dowels conforming to ASTM A276, Type 316.

B. Thoroughly grease expansion joint dowels prior to placing adjoining wall or slab concrete.

2.10. PVC EXPANSION SLEEVES

A. Single component dowel sleeve for use in expansion joints. 100% PVC material. Products:

1. Sika Speed Load.

2. Or accepted equivalent product.

PART 3 - EXECUTION

3.01. PVC WATERSTOPS

A. Heat splice at ends and intersections. Provide waterstops that provide a continuous, uninterrupted watertight diaphragm throughout the entire joint system below the high water level and below grade, unless noted otherwise on the Drawings.

B. Construct forms for construction joints to prevent injury to waterstops. Hold waterstops securely in position in the construction joints by wire ties, continuous bars, and rings as shown on the Contract Drawings. Install waterstops in construction joints in hydraulic structures and as shown on the Contract Drawings.

C. Use factory-made crosses, tees and ells. Make field splices with a thermostatically controlled heating iron in conformance with the manufacturer's current recommendations. Allow at least 10 minutes before pulling or straining the new splice in any way. The finished splices shall provide a cross section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced materials.

D. Provide waterstops with an integral fastening system consisting of grommets or pre-punched holes.

3.02. JOINTS

A. Make joints only at locations shown on the Contract Drawings or as permitted by the Engineer. Any addition or relocation of construction joints proposed by the Contractor must be submitted to the Engineer for written approval.

B. Cast slabs and beams monolithically without horizontal joints unless specifically indicated on the Drawings.

C. Do not use horizontal joints within foundation mats, base slabs, footings, or slabs on grade.

D. Provide waterstops in all wall and slab joints in liquid containment structures and at locations shown on the Contract Drawings. Do not provide metal waterstops unless permitted by the Engineer.

E. Construction Joints:

1. Provide waterstops at construction joints where shown on the Contract Drawings and specified herein.

2. Allow 7 days minimum between adjacent pours.

3. After the pour has been completed to the construction joint and the concrete has hardened, thoroughly clean the entire surface of the joint of surface laitance, loose concrete, foreign material, and expose clean aggregate by waterblasting the surface of construction joints before placing the new concrete.

4. In case of emergency, place additional construction joints. (An interval of 45 minutes between two consecutive batches of concrete shall constitute cause for an emergency construction joint.)

3.03. EXPANSION JOINTS

A. Size and location of expansion joints shall be as shown on the Contract Drawings.

B. Provide center bulb waterstop at expansion joints where shown on Contract Drawings and specified herein.

C. Do not extend reinforcement or other embedded items bonded to the concrete except dowels bonded on only one side of joint continuously through any expansion joint.

D. Install PVC sleeves and stainless steel expansion joint dowels parallel to wall or slab face, perpendicular to the joint face, and in true horizontal position. Align PVC sleeves and stainless steel expansion joint dowels as indicated in the Drawings. Secure tightly PVC sleeves and stainless steel expansion joint dowels in forms with rigid ties. Orient PVC sleeves and dowels to permit joint movement.

3.04. INSTALLATION OF JOINT SEALANTS

A. Immediately before installing the joint sealant, clean the joint cavity by sandblasting or power wire brushing. Install bond breaker tape per manufacturer's instructions.

B. Apply masking tape along the edges of the exposed surface of the exposed joints.

C. Application criteria for the sealant materials, such as temperature and moisture requirements and primer cure time, shall be in accordance with the recommendations of the sealant manufacturer.

D. After the joints have been prepared as described above, apply the joint sealant. Apply the primer, if required, and joint sealant only with the equipment and methods recommended by the joint sealant manufacturer.

E. Trowel the joints smooth with a tuck pointing tool wiped with a solvent recommended by the sealant manufacturer.

F. After the sealant has been applied, remove the masking tape and any sealant spillage.

G. Sealants used in water retaining structures shall achieve final cure at least seven days before the structure is filled with water.

3.05. FIELD QUALITY CONTROL

A. Contractor shall notify the Engineer of readiness for items under this Section to be inspected a minimum of 5 working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

3.06. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 03 21 00

REINFORCEMENT BARS

PART 1 - GENERAL

1.01. DESCRIPTION

A. Provide concrete reinforcement as indicated and specified.

B. Section Includes:

1. Standard reinforcement bars.
2. Weldable reinforcement bars at concrete corbels.
3. Welded wire reinforcement.
4. Reinforcement accessories.
5. Dowel adhesive material for anchoring reinforcing bars into hardened concrete.

1.02. REFERENCES

A. American Society for Testing and Materials (ASTM):

1. A82: Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. A185: Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
3. A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
4. A706: Standard Specification for Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

B. American Concrete Institute (ACI):

1. 301: Standard Specification for Structural Concrete.
2. 315: Details and Detailing of Concrete Reinforcement.
3. 318: Building Code Requirements for Structural Concrete.
4. SP-66: ACI Detailing Manual.

C. Concrete Reinforcing Steel Institute (CRSI):

1. Manual of Standard Practice.

2. Placing Reinforcing Bars.

D. International Code Council - Evaluation Services (ICC-ES):

1. ICC-ES Acceptance Criteria 308: Post-installed Adhesive Anchors in Concrete and Masonry Elements.

E. American Welding Society (AWS):

1. D1.4: Structural Welding Code, Reinforcement Steel.

F. Where reference is made to one of the above standards, the version in effect at the time of bid opening shall apply.

1.03. SUBMITTALS

A. Unless otherwise acceptable to the Engineer, each submittal shall include reinforcement only for the individual structure to which it pertains.

B. Shop Drawings:

1. Submit bar lists and placing drawings for all reinforced concrete structures in accordance with Section 01 33 00.

2. Detail reinforcement in conformance with ACI SP-66.

3. Clearly indicate bar sizes, spacings, locations and quantities of reinforcement steel and wire reinforcement, bending schedules, and supporting and spacing devices. Show joints, with applicable joint reinforcement.

4. Clearly indicate reinforcement to be welded.

5. Coordinate bar splicing and placement with Contractor's concrete placing schedule and joint locations. Do not add or delete joints without permission from the Engineer.

6. Show wall reinforcement in elevation.

7. Show slab reinforcement in plan view.

8. Show location and size of all penetrations greater than 12-inches in diameter or least dimension of the opening with the corresponding added reinforcement around the penetrations.

9. Clearly show marking for each reinforcement item.

10. Indicate locations of reinforcement bar cut-offs, splices and development lengths.

C. Submit certified copies of mill test reports of reinforcement analysis for each shipment of reinforcement with specific lots in shipments identified.

D. Chemical composition of reinforcement steel: Ladle analysis indicating percentage of carbon, phosphorous, manganese and sulfur present in steel.

E. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, submit Manufacturer's literature that contains instructions and recommendations for installation for each type of coupler used; certified test reports that verify the load capacity of each type and size of coupler used; and Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.

F. Submit AWS qualification certificates for welders employed on the Work for the appropriate electrode and class of material. Testing shall be conducted and witnessed by an independent testing laboratory prior to welding reinforcement in work. Maintain qualification and certification records at the job site, readily available for examination of test results.

1.04. QUALITY ASSURANCE

A. Provide ICC-ES evaluation report for the dowel adhesive.

1.05. QUALITY ASSURANCE

A. Do not fabricate reinforcement until shop and placement drawings have been reviewed and accepted by the Engineer.

B. Perform concrete reinforcement work in accordance with CRSI Manual of Standard Practice.

C. In no case shall any reinforcement steel be covered with concrete until the installation of the reinforcement has been observed by the Engineer and the Engineer’s authorization to proceed with the concreting has been obtained. The Engineer shall be given 5 working days minimum prior notice of the readiness of placed reinforcement for observation. The forms shall be kept open until the Engineer has finished observations of the reinforcement steel.

1.06. DELIVERY STORAGE AND HANDLING

A. Keep reinforcement steel free from mill scale, rust, dirt, grease or other foreign matter.

B. Ship and store reinforcement steel with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same "mark" designations as those shown on the submitted placing drawings. Clearly label weldable reinforcement.

C. Store reinforcement steel off the ground, protected from moisture and kept free from dirt, oil or other injurious contaminants.

PART 2 - PRODUCTS

2.01. REINFORCEMENT STEEL

A. Reinforcement Steel (Not Welded): ASTM A615/A615M, 60 ksi yield grade; deformed billet steel bars, unfinished.

B. Welded Reinforcement Steel (for Concrete Corbels): ASTM A706/A706M, 60 ksi yield strength; deformed low-alloy steel bars, unfinished.

C. Provide support bars and reinforcement bar supports as specified herein to obtain the concrete cover indicated.

D. Welded Wire Reinforcement:

1. Provide welded wire reinforcement conforming to ASTM A185 in flat sheets.

2. Provide support bars and reinforcement bar supports as specified herein to obtain the concrete cover indicated.

2.02. ACCESSORY MATERIALS

A. Tie Wire: Minimum 16 gage annealed type.

B. Chairs, Bolsters, Bar Supports, and Spacers: sized and shaped for strength and support of reinforcement during concrete placement.

C. Special Chairs, Bolsters, Bar Supports, and Spacers Adjacent to Weather Exposed Concrete Surfaces: plastic coated steel, stainless steel, or plastic type; size and shape.

D. Provide 3-inch by 3-inch plain precast concrete blocks, precast concrete doweled blocks or concrete brick for support of bottom reinforcement in foundation mats, base slabs, footings, pile caps, grade beams and slabs on grade. Provide block thickness to produce concrete cover of reinforcement as indicated.

E. Mechanical Couplers:

1. Reinforcement Tension Bar Splicers:

a. Manufacturers: Cadweld or Lenton rebar splicers by Erico Products, Inc. and Dayton Barsplice, Inc.

b. Manufacturers: DB-SAE splicer system by Richmond Screw Anchor Company, Inc., C2D rebar flange coupler by Williams Form Engineering Corporation and Lenton Form Saver by Erico Products, Inc.

c. Develop minimum 125 percent of yield capacity of bars spliced in tension when tested as an assembly in accordance with ASTM A370 and A615.

2. Reinforcement Compression Bar Splicers:

a. Manufacturers: G-Loc splicers by Gateway Building Products Division and Speed-Sleeve by Erico Products, Inc.

F. Dowel Adhesive (Epoxy):

1. Install dowel adhesive in full compliance with the adhesive manufacturer's recommendations.

2. Product:

a. Hilti Corporation, HIT-RE 500 V3.

b. Or acceptable equivalent product.

2.03. FABRICATION

A. Fabricate concrete reinforcement in accordance with CRSI Manual of Standard Practice.

B. Weld reinforcement in accordance with AWS D1.4 only when permitted by the Engineer.

C. Locate reinforcement splices not indicated on Drawings, at point of minimum stress. Review location of splices with Engineer.

D. Cold bend bars. Do not straighten or rebend bars.

E. Do not heat reinforcement steel to bend or straighten.

F. Bend bars around a revolving collar having a diameter of not less than that recommended by ACI 318.

PART 3 - EXECUTION

3.01. INSTALLATION

A. Place, support and secure reinforcement against displacement. Do not deviate from the required position. Place reinforcement a minimum of 2-inches clear of any metal pipe or fittings.

B. Position dowels accurately. Rigidly support, align and securely tie dowels normal to the concrete surface before concrete placement. Setting dowels into wet concrete is prohibited.

C. Bars additional to those indicated that may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at no additional cost to Maine DMR.

D. Provide additional reinforcement bars to support top reinforcement in slabs. Do not shift reinforcement bars from positions in upper layers to positions in lower layers as a substitute for additional support bars.

E. Support reinforcement steel in accordance with CRSI “Placing Reinforcement Bars” with maximum spacing of 4 feet-0 inches.

F. Tie reinforcement steel at intersections in accordance with CRSI “Placing Reinforcement Bars”:

1. Maximum tie spacing for footings, walls and columns: every third intersection or 3 feet-0 inches.

2. Maximum spacing for slabs and other work: every fourth intersection or 3 feet-0 inches.

3. Tie a minimum of 25 percent of all intersecting bars in foundation mats, base slabs, footings, and slabs on grade.

4. Secure all dowels in place before placing concrete.

5. Tie wires shall be bent away from the forms and from finished concrete surfaces in order to provide the required concrete coverage.

G. Locate reinforcement to avoid interference with items drilled in later, such as concrete anchors.

H. Extend welded wire reinforcement to within 2 inches of edges of slab or section. Lap sheets at least 12 inches or two wire spaces, whichever is greater, at ends and edges and wire tightly together. Stagger end laps.

I. Support welded wire reinforcement placed over horizontal forms on slab bolsters spaced not more than 30 inches on center.

J. Mechanical coupler systems may be substituted for dowels at Contractor’s option when permitted by Engineer.

K. Provide additional reinforcement bars to support ties and stirrups in beams where top reinforcement is not continuous.

L. Securely support and tie reinforcement steel to prevent movement during concrete placement.

M. Unless otherwise shown on the Drawings or permitted by the Engineer, do not bend reinforcement bars that project from in-place concrete.

N. Do not weld reinforcement steel bars (including tack welded) either during fabrication or erection unless specifically shown on the Drawings or specified herein, or unless prior written permission has been obtained from the Engineer. Immediately remove bars that have been welded, including tack welds, without such permission from the work.

O. Reinforcement steel interfering with the location of other reinforcement steel, conduits, or embedded items may be moved within the specified tolerances or one bar diameter, whichever is greater. Make greater displacement of bars to avoid interference only with the permission of the Engineer. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without prior permission from the Engineer.

P. Reinforcement shall be clean and free from loose mill scale, dirt, grease, oil, form release agent, dried concrete or any material reducing bond with concrete.

Q. Setting bars and welded wire reinforcement on layers of fresh concrete as the work progresses or adjusting reinforcement during the placement of concrete is prohibited.

R. Provide and place safety caps on all exposed ends of vertical reinforcement that pose a danger to injury or life safety.

3.02. CONCRETE COVER OVER REINFORCEMENT BARS

A. Refer to the Drawings for concrete cover over reinforcement.

3.03. REINFORCEMENT AROUND OPENINGS AND PENETRATIONS

A. Accommodate placement of formed openings and penetrations.

B. Unless specific additional reinforcement around openings and penetrations is shown on the Drawings, provide additional reinforcement steel on each side of opening or penetration equivalent to one half of the cross-sectional area of the reinforcement steel interrupted by an opening or penetration. The bars shall have sufficient length to be fully developed at each end beyond the opening or penetration.

C. Refer to details on Drawings for additional diagonal bars around openings or penetrations and bar extension length on each side of openings or penetrations.

3.04. SPLICING OF REINFORCEMENT

A. Splices may be used to provide continuity due to bar length limitations. The minimum length of bars spliced for this reason is 30 feet. Do not splice reinforcement that is detailed to be continuous in the Drawings.

B. Stagger bar splices.

C. ACI 318 Class B Splices shall be used unless noted otherwise.

D. Make reinforcement continuous through construction joints.

E. Reinforcement may be spliced at construction joints provided that entire lap is placed within only one concrete placement.

3.05. ACCESSORIES

A. Provide accessories such as chairs, chair bars and the like in sufficient quantities and strength to adequately support the reinforcement and prevent its displacement during the erection of the reinforcement and the placement of concrete.

B. Use precast concrete blocks for the bottom mat of reinforcement where the reinforcement steel is to be supported over soil.

C. Provide stainless steel bar supports or steel chairs with plastic tips where the chairs are set on forms for a concrete surface that will be exposed to weather, high humidity or liquid (including bottom of slabs over liquid containing areas) unless otherwise noted on contract documents.

D. Do not use metal chairs, ferrous clips, nails, etc. that extend to the surfaces of the concrete. Do not use stones, brick or wood block supports.

E. Do not use alternate methods of supporting top steel in slabs, such as steel channels supported on the bottom steel or vertical reinforcement steel fastened to the bottom and top mats unless permitted by the Engineer.

F. Mechanical Couplers:

1. Couplers that are located at a joint face can be a type that can be set either flush or recessed from the face as indicated.

2. Seal couplers during concrete placement to completely eliminate concrete or cement paste from entering.

3. Recess couplers intended for future connections a minimum of 1/2 inch from the concrete surface. After the concrete is placed, plug the coupler with plastic plugs that have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials.

4. Unless indicated otherwise, provide mechanical coupler spacing and size to match the spacing and size of the reinforcement indicated for the adjacent section.

G. Dowel Adhesive:

1. Install dowels in accordance with adhesive manufacturer recommendations. Embedment depth of dowels shall be as recommended by the adhesive manufacturer, but not less than as shown on the Drawings.

3.06. FIELD QUALITY CONTROL

A. Contractor shall notify the Engineer of readiness for items under this Section to be inspected a minimum of five working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

B. Remove reinforcement with kinks or bends not shown on shop or placement drawings. Remove such reinforcement from job site and replace with new fabricated steel. Do not field bend reinforcement unless reinforcement is indicated or specified to be field bent.

C. Protect reinforcement from rusting, deforming, bending, kinking and other injury. Clean in-place reinforcement that has rusted, or been splattered with concrete using sand or water blasting prior to incorporation into the Work.

3.07. CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01. DESCRIPTION

A. Provide labor, materials, equipment and incidentals necessary to furnish and install cast-in-place concrete as specified and as shown on the Contract Drawings.

1.02. REFERENCES

A. American Concrete Institute (ACI):

1. 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
2. 214R: Guide to Evaluation of Strength Test Results of Concrete.
3. 301: Standard Specifications for Structural Concrete.
4. 304R: Guide for Measuring, Mixing, Transporting and Placing Concrete.
5. 304.2R: Placing Concrete by Pumping Methods.
6. 305R: Hot Weather Concreting.
7. 306R: Cold Weather Concreting.
8. 308: Standard Practice for Curing Concrete.
9. 309R: Guide for Consolidation of Concrete.
10. 311.4R: Guide for Concrete Inspection.
11. 318: Building Code Requirements for Structural Concrete.
12. 350: Code Requirements for Environmental Engineering Concrete Structures and Commentary.

B. American Society for Testing and Materials (ASTM):

1. C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field.
2. C33: Standard Specification for Concrete Aggregates.

3. C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

4. C40: Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

5. C42: Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

6. C88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

7. C94: Standard Specification for Ready-Mixed Concrete.

8. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or [50-mm] Cube Specimens).

9. C138: Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.

10. C143: Standard Test Method for Slump of Hydraulic Cement Concrete.

11. C150: Standard Specification for Portland Cement.

12. C171: Standard Specification for Sheet Materials for Curing Concrete.

13. C172: Standard Practice for Sampling Freshly Mixed Concrete.

14. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

15. C260: Standard Specification for Air-Entraining Admixtures for Concrete.

16. C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

17. C494: Standard Specification for Chemical Admixtures for Concrete.

18. C595: Standard Specification for Blended Hydraulic Cements.

19. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

20. C881: Standard Test Method for Epoxy Resin Base Bonding Systems for Concrete.

21. C989: Standard Specification for Slag Cement for Use in Concrete and Mortars.

22. C1017: Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

23. C1064: Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.

24. C1260: Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

25. C1567: Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).

26. D4101: Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials.

27. D4832: Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.

28. D6103: Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM).

C. American Association of State Highway and Transportation Officials (AASHTO):

1. M182: Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.

2. M302: Standard Specification for Slag Cement for Use in Concrete and Mortars.

1.03. SUBMITTALS

A. Submit the following shop drawings in accordance with 01 33 00.

B. Testing required under Article 1.03 is the responsibility of the Contractor and shall be provided at no additional cost to Maine DMR.

C. If during the progress of the work the materials from the sources originally accepted change in characteristics, the Contractor shall at their own expense make new acceptance tests of aggregate and establish new design mixes.

D. If during the progress of the work it is impossible to secure concrete of the required workability and strength with the materials being furnished, the Engineer may order changes in proportions, materials or both, as may be necessary to secure the desired properties. All changes so ordered shall be made at the Contractor’s expense.

E. Plant Qualification: Submit certification from the National Ready Mixed Concrete Association indicating compliance with the specified qualification requirements.

F. Product Data:

1. Manufacturer's specifications and instructions including ASTM Standards conformance and Material safety Data Sheets (MSDS) for admixtures and curing materials. Manufacturer’s certification of compatibility of all admixtures.

2. Manufacturer’s product data for the manhole steps (rungs).

G. Shop Drawings:

1. Provide certificate that cement used complies with ASTM C595 and these specifications.

2. Provide certificates that aggregates comply with required ASTM standards. Submit gradation analysis with concrete mix designs. Include source/location of aggregates. Potential alkali reactivity (ASTM C1567) test results for each aggregate type and source.

3. Provide certificate of compliance with these specifications from the manufacturer of the concrete admixtures.

4. For each formulation of concrete proposed, provide concrete mix designs and laboratory 7-day and 28-day compressive tests, or submit test results of 7- and 28-day compressive tests of the mix where the same mix has been used on two previous projects in the past twelve months. Follow standards of concrete control per the statistical principles of ACI 214R.

5. As a minimum each concrete mix design submittal shall include but is not limited to containing the following information.

   a. 7-day and 28-day compression test results. Include mean and standard deviation for test results on each 7 or 28-day group.

   b. Constituent quantities per cubic yard.

   c. Water cementitious materials ratio.

   d. Concrete slump.

   e. Air content.

   f. Water soluble chloride ion content of any individual components of the proposed mix.

g. Type of concrete mix.

h. Manufacturer of cementitious products.

i. Sources of cement, pozzolan, and aggregates.

j. Letter certifying that the admixtures used in the same concrete mix are compatible with each other, as well as the aggregates.

6. Submit layout for joints and plan for joint surface preparation.

7. Proposed special procedures for protection of concrete under wet weather placement conditions.

8. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.

H. Manufacturers' Instructions:

1. Provide epoxy bonding compound and non-epoxy compound manufacturer's specific instructions for use. Provide manufacturer's data sheets as to suitability of product to meet job requirements regarding surface, pot life, set time, vertical or horizontal application, and forming restrictions.

I. Field Quality Control Submittals:

1. Provide delivery tickets for ready-mix concrete or weighmasters certificate per ASTM C94, including weights of cement and each size aggregate and amount of water added at the plant and record of pours. Record the amount of water added on the job on the delivery ticket. Water added at the plant shall account for moisture in both coarse and fine aggregate. If it is necessary to add water to obtain the specified slump, add water per ASTM C94, but do not exceed the water content of the approved design mix.

1.04. QUALITY ASSURANCE

A. Unless otherwise indicated, materials, workmanship, and practices shall conform to the following standards:

1. ACI 301, "Structural Concrete for Buildings.”

2. ACI 318, "Building Code Requirements for Reinforced Concrete.”

3. ACI 350, “Code Requirements for Environmental Engineering Concrete Structures.”

B. Where provisions of pertinent codes and standards conflict with this specification, the more stringent provisions govern.

C. Concrete not meeting the minimum specified 28-day design strength shall be cause for rejection and removal from the Work.

D. Perform concrete work in conformance with ACI 301 unless otherwise specified.

E. Do not use admixtures, including calcium chloride, which will cause accelerated setting of cement in concrete.

F. Provide and complete a pre-placement checklist.

G. Do not place concrete until design mix, material tests and trial concrete batch mix compression test results are accepted by the Engineer.

H. Employ an independent testing laboratory, acceptable to the Engineer, to develop concrete mix designs and testing. Concrete testing shall be performed by an ACI Concrete Field Technician, Grade I or equivalent. Refer to Article 1.03 above.

I. The Contractor shall employ an independent testing laboratory to perform field testing in order to verify conformity of materials to specifications. Field concrete testing shall be performed by an ACI Concrete Field Technician, Grade I or equivalent. Contractor shall allow free access to obtain test samples.

J. Concrete samples to be taken as part of the required Field Testing, shall be taken at the point of placement.

K. Methods of Sampling and Testing:

    1. Fresh Concrete Sampling: ASTM C172.

    2. Specimen Preparation: ASTM C31.

    3. Compressive Strength: ASTM C39.

    4. Air Content: ASTM C231.

    5. Slump: ASTM C143.

    6. Temperature: ASTM C1064.

    7. Unit Weight: ASTM C138.

    8. Obtaining Drilled Cores: ASTM C42.

L. Acceptance of Structure: Acceptance of completed concrete work requires conformance with dimensional tolerances, appearance and strength as indicated or specified.

M. Do not cover up or enclose work until it has been properly and completely inspected, tested, and approved.

N. Should any of the work be covered up or enclosed prior to all required inspections, tests, and approvals, uncover the work as required for test and inspection. After inspection, tests, and approval, make all repairs and replacements with such materials as are necessary to the approval of Maine DMR and at no additional cost to Maine DMR. Retest as required to verify that all work is in accordance with the specifications.

O. Hot weather concrete to conform to ACI 305R and as specified herein.

P. Cold weather concrete to conform to ACI 306R and as specified herein.

Q. Reject concrete delivered to job site that exceeds the time limit or temperature limitations specified.

R. Do not place structural concrete in water or on frozen or uncompacted ground.

S. Workability:

1. Concrete shall be of such consistency and composition that it can be worked readily into the forms and around the reinforcement without excessive vibrating and without permitting the materials to segregate or free water to collect on the surface.

2. Adjust the proportions to secure a plastic, cohesive mixture, and one that is within the specified slump range and water cementitious ratio.

3. To avoid unnecessary changes in consistency, obtain the aggregate from a source with uniform quality, moisture content, and grading. Handle materials to minimize variations in moisture content that would interfere with production of concrete of the established degree of uniformity and slump.

1.05. DELIVERY, STORAGE, AND HANDLING

A. Deliver concrete to discharge locations in watertight agitator or mixer trucks without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.

B. Reject concrete not conforming to specification, unsuitable for placement, exceeding the time or temperature limitations or not having a complete delivery batch ticket.

1.06. SITE CONDITIONS

A. Do not place concrete until conditions and facilities for making and curing control test specimens are in compliance with ASTM C31 and as specified herein.

PART 2 - PRODUCTS

2.01. MATERIALS

A. Cement:

1. Portland Cement, ASTM C595, Type IL.

2. Use only one brand of cement in any individual structure. Use no cement that has become damaged, partially set, lumpy, or caked. Reject the entire contents of the sack or container that contains such cement. Use no salvaged or reclaimed cement.

3. Maximum tricalcium aluminate shall not exceed 8 percent. The maximum percent alkalies shall not exceed 0.6 percent.

B. Fly Ash:

1. Provide fly ash conforming to the following requirements:

a. Class F fly ash conforming to ASTM C618 for chemical and physical properties.

2. Supplemental requirements in percent:

a. Maximum carbon content: 3 percent.

(1) Maximum sulfur trioxide (SO3) content: 4 percent.

(2) Maximum loss on ignition: 3 percent.

(3) Maximum water requirement (as a percent of control): 100 percent.

C. Slag Cement:

1. Slag cement shall conform to the chemical and physical requirements of ASTM C989, Grade 100 or better.

D. Fine Aggregates:

1. Clean, sharp, natural sand conforming to requirements of ASTM C33 with a fineness modulus between 2.50 and 3.0.

2. All aggregate shall be innocuous per ASTM C1260 or C1567; less than 0.10 percent expansion.

E. Coarse Aggregate:

1. Well graded crushed stone, natural rock conforming to requirements of ASTM C33.

2. Limit deleterious substances in accordance with ASTM C33, Table 3, Severe Weathering Regions, limit clay lumps not to exceed 1.0 percent by weight, and limit loss when tested for soundness using magnesium sulfate to 12 percent.

3. All aggregate shall be innocuous per ASTM C1260 or C1567; less than 0.10 percent expansion.

F. Water and Ice:

1. Use water and ice free from injurious amounts of oil, acid, alkali, salt, organic matter or other deleterious substances and conforms to requirements of ASTM C94.

2. Water shall not contain more than 500 mg/L of chlorides nor more than 500 mg/L of sulfate.

3. Heat or cool water to obtain concrete temperatures specified, and in conformance with ACI 305R and ACI 306R.

G. Color Additive for Exterior Electrical Duct Encasement:

1. For exterior electrical duct concrete encasements, use a color additive for identification purposes.

H. Concrete Admixtures:

1. Maintain compressive strength and maximum water-cement ratios specified in Table 03 30 00-1 when using admixtures. Include admixtures in solution form in the water-cement ratio calculations.

2. Do not use any admixture that contains chlorides or other corrosive elements in any concrete. Admixtures shall be nontoxic after 30 days.

3. Hydration controlling admixtures may be used but shall be submitted for approval and identified clearly on all batch tickets.

4. Use admixtures in compliance with the manufacturer’s printed instructions. The manufacturer shall certify the compatibility of multiple admixtures used in the same mix.

5. Do not use admixtures in greater dosages than recommended by manufacturer.

6. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

7. Air Entrainment:

   a. Class A concrete; an air-entraining admixture conforming to ASTM C260.

   b. Products:

      (1) BASF Corporation; MB-AE 90.

      (2) Sika Corporation, AER.

      (3) Or accepted equivalent product.

   c. Adjust the admixture content to accommodate fly ash or pozzolan requirements, and other admixtures when used, in order to obtain the specified air content.

8. Water Reducing:

   a. For Class A concrete a water-reducing admixture conforming to ASTM C494, Type A and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.

   b. Products:

      (1) BASF Corporation; Polyheed Series.

      (2) Sika Corporation, Plastocrete 161.

      (3) WR Grace & Co.; Darex II-AEA.

      (4) Euclid Chemical Company; Eucon NW.

      (5) Or accepted equivalent product.

9. Water Reducing and Retarding:

a. For Class A concrete a water-reducing and retarding admixture conforming to ASTM C494, Type D and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.

b. Products:

(1) BASF Corporation; Pozzolith Series.

(2) Sika Corporation; Plastiment.

(3) Euclid Chemical Company; Eucon WR-91.

(4) Or accepted equivalent product.

10. High-Range Water-Reducing Admixture (Superplasticizer):

a. For Class A concrete a High-Range water-reducing admixture conforming to ASTM C494, Type F or ASTM C1017, Type I.

b. Products:

(1) BASF Corporation; Glenium Series.

(2) WR Grace & Co.; Daracem 100.

(3) Euclid Chemical Company; Eucon SPC.

(4) Or accepted equivalent product.

11. Hydration Controlling Admixture:

a. Hydration controlling admixture conforming to ASTM C494 and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.

b. Products:

(1) BASF Corporation; DELVO Stabilizer.

(2) Sika Corporation; SikaTard 440.

(3) Or accepted equivalent product.

I. Bonding Compound:

1. Epoxy bonding compound shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives. The class of epoxy bonding compound shall be suitable for ambient and substrate temperatures.

   a. Products:

      (1) Sika Corp.; Sikadur 32.

      (2) Euclid Chemical Company; Duralcrete.

      (3) BASF Corporation, Concresive Liquid LPL.

      (4) Or accepted equivalent product.

2. Non-epoxy bonding compound shall be Weldcrete by Larsen Products Corp., Link by Sta-Dry Manufacturing Corp., Euco Weld by Euclid Chemical Co., or equivalent.

J. Curing Compound:

1. Liquid form, which will form impervious membrane over, exposed surface of concrete when applied to fresh concrete by means of spray gun. Use Type I, Class A or B, having 18 percent minimum solids conforming to ASTM C309.

2. Products:

   a. BASF Building Systems; Kure 1315.

   b. Euclid Chemical Company; Super Diamond Clear VOX.

   c. W. R. Meadows, Inc.; VOCOMP-30.

   d. Dayton Superior Corp; Safe Cure and Seal 30 percent.

   e. Or accepted equivalent product.

K. Burlap Mats:

1. Conform to AASHTO M182.

L. Sisal-Kraft Paper and Polyethylene Sheets for Curing:

1. Conform to ASTM C171.

2.02. MIXES

A. Conform to ASTM C94, except as modified by these specifications.

B. Air content as determined by ASTM C231:

1. 5 ± 1½ percent for concrete using 1½-inch maximum aggregate size.

2. 5 ½ ± 1½ percent for concrete using 1-inch maximum aggregate size.

3. 6 ± 1½ percent for concrete using ¾-inch maximum aggregate size.

4. No air entrainment required for Class C tremie concrete.

C. Provide concrete with the following compressive strengths at 28 days and proportion it for strength and quality requirements in accordance with ACI 318. The resulting mix shall not conflict with limiting values specified in Table 03 30 00-1.

Table 03 30 00-1				
Class	**Type of Work**	**28-Day Minimum Compressive Strength (psi)**	**Minimum Cementitious Content (lbs per C.Y.)**	**Maximum Water/ Cement Ratio**
A	Concrete for all structures and concrete not otherwise specified	4,500	560	0.42
B	Pavement, concrete topping, and electrical encasement	3,000	500	0.54
C	Tremie concrete and concrete fill below structure foundations	4,500	560	0.45
FF	Flowable Fill	Refer to "FLOWABLE FILL," specified below		

D. Measure slump in accordance with ASTM C143:

1. Proportion and produce the concrete to have a maximum slump of 4 inches. A tolerance of up to 1 inch above the indicated maximum is allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

2. Mixes containing water reducers shall have a maximum slump of 6 inches after the addition of a mid-range water reducer and maximum slump of 8 inches after the addition of a high range water reducer.

E. Pozzolan Content:

1. Where fly ash is included in the mix, the fly ash content shall be no less than 15 percent, nor more than 20 percent of the total cementitious content by weight.

2. Slag cement will be permitted as a substitute for fly ash at no additional cost to Maine DMR, in the event that Class F fly ash is not available. The slag substitution shall be in the same proportions and percentages of the total cementitious material as shown for fly ash.

F. Aggregate Size shall be:

1. ¾-inch maximum for tremie concrete placement;

2. ¾-inch maximum for slabs and sections 8-inches thick and less;

3. 1-inch maximum for sections greater than 8-inches and less than 17-inches; and

4. 1 ½-inches maximum for all slabs and sections greater than 17-inches.

5. Combined aggregate grading shall be as shown in the following table:

Table 03 30 00-2				
Maximum Aggregate Size	**1-1/2 inch**	**1 inch**	**3/4-inch**	**3/8-inch**
Aggregate Grade per ASTM C33	467	57	67	8

2.03. FLOWABLE FILL

A. Flowable fill (flowfill) shall consist of a fluid, workable mixture of aggregate, fly ash, cement, and water.

B. Aggregate shall be composed of 75% to 80% fine aggregate, measured by weight, and 20% to 25% coarse aggregate.

C. Fine aggregate: composed of commercial quality concrete sand.

D. Coarse aggregate: conform to the grading and quality requirements of ASTM C33 for size No. 7.

E. Proportion the aggregate, fly ash, cement, and water by either weight or volume. Include at least 50 pounds of cement per cubic yard produced. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed.

F. Thoroughly machine-mix the materials for the flowable fill in pugmill, rotary drum, or other mixer. Continue the mixing until the cement and water are thoroughly dispersed throughout the material. Place flowable fill within 1-hour after mixing.

G. Flowable fill shall have a minimum 28-day compressive strength of 100 psi, measured in accordance with ASTM D4832.

H. Flowable fill shall have minimum flow consistency of 7 inches and a maximum flow consistency of 9 inches, measured in accordance with ASTM D6103.

2.04. MANHOLE STEPS (RUNGS)

A. Steps (ladder rungs) shall be 1/2-inch minimum diameter steel reinforced bar with a polypropylene plastic covering (per ASTM D4101).

B. Minimum clear length of rungs shall be 14 inches.

C. Space rungs vertically at 12-inches, on center, set between 5- and 6-inches from the face of the concrete, and align with each other in a straight vertical line (both parallel and perpendicular to ladder rungs).

D. Steps shall be Lane International P-14938, or equal.

PART 3 - EXECUTION

3.01. INSPECTION

A. Examine the subgrade and the conditions under which work is to be performed and notify the Engineer in writing of unsatisfactory conditions. Do not proceed with the work until unsatisfactory conditions are corrected to comply with specified subgrade conditions in a manner acceptable to the Engineer.

3.02. MIXING AND TRANSPORTING CONCRETE

A. General: Conform to concreting procedures set forth in ASTM C94, ACI 304R and as specified herein. Concrete shall be rejected if it does not meet these Specifications.

1. Transport concrete to discharge locations without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.

2. Discharge concrete into forms within 1-1/2 hours after cement has entered mixing drum or before the drum has revolved 300 revolutions after the addition of water, whichever occurs first.

3. Do not add water at the jobsite unless permitted by the Engineer. If it is necessary to add water to obtain the specified slump, add water per ASTM C94, but do not exceed the maximum water content in the reviewed concrete design mix. Added water shall be incorporated by additional mixing of at least 35 revolutions.

4. Do not add water to concrete containing high range water reducing admixture. Do not add water to concrete in delivery equipment not acceptable for mixing.

5. Keep a record showing time and place of each pour of concrete, together with transit-mix delivery slips certifying the contents of the pour.

6. Discharge of concrete shall be completed within the limits set out in Table 03 30 00-3.

Table 03 30 00-3			
Time Limit for Concrete Placement			
Air Temperature	**Required Concrete Temperature Limits**	**Hydration Controlling Admixture Required**	**Time Limit for Completion of Placing After Initial Mixing**
< 32 degrees F	60 to 75 degrees	No	150 minutes
32 - 60 degrees F	50 to 80 degrees	No	120 minutes
60 - 85 degrees F	85 degrees max	No	90 minutes
60 - 85 degrees F	85 degrees max	Yes	120 minutes

B. Conveying: Convey concrete from agitator or mixer truck to place of final deposit in forms by one of the following methods:

1. Buckets or hoppers with discharge gates having a clear opening equal to not less than one-third the maximum interior horizontal area or five times the maximum aggregate size being used, whichever is greater, and side slopes of not less than 60 degrees to horizontal.

2. Buggies or wheelbarrows equipped with pneumatic tires.

3. Round bottom, metal or metal-lined chutes with inclined slope of between 2- to 3-feet horizontally to 1-foot vertically and of sufficient capacity to avoid overflow.

4. Circular drop pipes with a top diameter of at least eight times the maximum aggregate size, but not less than 6-inches, or tapered to not less than six times maximum aggregate size.

3.03. CONCRETE ACCEPTANCE

A. Accept or reject each batch of concrete delivered to the point of agitator or mixer truck discharge. Sign delivery batch tickets to indicate concrete acceptance.

B. Reject concrete delivered without a complete concrete delivery batch ticket as specified herein. The concrete supplier will furnish copies of the signed batch ticket to the Contractor and Engineer.

C. The Testing Agency shall perform field tests at the point of placement. Accept or reject concrete on the basis of conformity with slump, air content and temperature specified.

D. The Testing Agency shall inspect concrete transit truck's barrel revolution counter and gauge for measuring water added to the concrete. Reject concrete that exceeds the maximum barrel revolution of 300, the limits in Table 03 30 00-3 or concrete that has water content exceeding the specified water-cement ratio.

E. Reject concrete not conforming to specification before discharging into the forms.

3.04. PREPARATION AND COORDINATION

A. Contractor shall notify the Engineer of readiness to place concrete in any portion of the work a minimum of 5 working days prior to concrete placement. Failure to provide this notification will be cause for delay in placing until observations can be completed. Contractor shall develop emergency/backup procedures that are approved prior to concrete delivery.

B. Coordinate the sequence of placement such that construction joints will occur only as designed.

C. Schedule sufficient equipment for continuous concrete placing. Provide backup equipment (cranes/excavators/loaders with concrete buckets, etc.) and procedures to be taken in case of an interruption in concrete placement. Provide backup concrete vibrators at the project site. Test concrete vibrators the day before placing concrete.

D. Compact the subgrade and/or bedding. Saturate the subgrade approximately eight hours before placement and sprinkle ahead of the placement of concrete. Remove standing water, mud, and foreign matter before concrete is deposited.

E. Where shown on the Contract Drawings, intentionally roughen surfaces of set concrete in a manner to expose bonded aggregate uniformly at joints.

3.05. CONCRETE PLACEMENT

A. Placement shall conform to ACI 304R as modified by these specifications.

B. Concrete shall be placed only in the presence of the Engineer or a duly authorized representative.

C. Alternating sections of concrete walls and slabs may be cast simultaneously. Do not place adjacent sections of walls and slabs until seven days after placement of first placed concrete.

D. Refer to the Drawings for additional requirements for concrete placements related to the individual structures associated with the Project.

E. Unless tremie concrete placement has been approved by the Engineer, do not place concrete until free water has been removed or has been diverted by pipes or other means and carried out of the forms, clear of the work. Do not deposit concrete underwater, and do not allow free water to rise on any concrete until the concrete has attained its initial set. Do not permit free or storm water to flow over surfaces of concrete so as to injure the quality or surface finish.

F. Do not place concrete during inclement weather. Protect concrete placed from inclement weather. Keep sufficient protective covering ready at all times for this purpose.

G. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing. Do not deposit concrete in large quantities in one place to be worked along the forms with a vibrator.

H. Deposit concrete continuously and in level layers 1 to 2 feet thick. Avoid inclined layers and cold joints. Place concrete at lower portion of slope first on sloping surfaces.

I. Do not deposit partially hardened concrete in forms. Retempering of partially hardened concrete is not permitted. Remove partially hardened concrete from site at no additional compensation.

J. Do not allow concrete to fall freely in forms to cause segregation (separation of coarse aggregate from mortar). Limit maximum free fall of concrete to 4 feet. Do not move concrete horizontally more than four feet from point of discharge. Space points of deposit not more than eight feet apart.

K. At least two hours shall elapse after depositing concrete in the columns or walls before depositing in beams, girders, or slabs supported thereon. Place beams, girders, brackets, column capitals, and haunches monolithically as part of the floor or roof system, unless otherwise shown on the Contract Drawings.

L. Consolidate concrete using mechanical vibrators operated within the mass of concrete and/or on the forms conforming to procedures set forth in ACI 309R and as specified herein.

M. Conduct vibration to produce concrete of uniform texture and appearance, free of honeycombing, streaking, cold joints or visible lift lines.

N. Conduct vibration in a systematic manner with regularly maintained vibrators. Furnish sufficient backup units at job site. Use vibrators having minimum frequency of 8,000 vibrations per minute and of sufficient amplitude to consolidate concrete. Use not less than one vibrator with crew for each 35 to 40 cubic yards of concrete placed per hour.

O. Insert and withdraw vibrator vertically at a uniform spacing over the entire area of placement. Space distances between insertions such that spheres of influence of each insertion overlap.

P. Use additional vibration with pencil vibrators on vertical surfaces and on exposed concrete to bring full surface of mortar against the forms so as to eliminate air voids, bug holes and other surface defects. Employ the following additional procedures for vibrating concrete as necessary to maintain proper consolidation of concrete:

1. Reduce distance between internal vibration insertions and increase time for each insertion.

2. Insert vibrator as close to face of form as possible without contacting form or reinforcement.

3. Use spading as a supplement to vibration where particularly difficult conditions exist.

Q. Pumping Concrete:

1. Conform to the recommendations of ACI 304.2R except as modified herein.

2. Base pump size on rate of concrete placement, length of delivery pipe or hose, aggregate size, mix proportions, vertical lift, and slump of concrete.

3. Use pipe with inside diameter of at least three times the maximum coarse aggregate size, but not less than 2 inches.

4. Do not use aluminum pipes for delivery of concrete to the forms.

R. Waterstops:

1. Prevent displacement of waterstops during concrete placement.

3.06. CURING AND PROTECTION

A. General:

1. Protect concrete from premature drying, hot or cold temperatures, and mechanical injury, beginning immediately after placement and maintain concrete with minimal moisture loss at relatively constant temperature.

2. Comply with curing procedures set forth in ACI 301, ACI 308 and as specified herein.

3. Perform hot weather concreting in conformance with ACI 305R and as specified herein when the ambient atmospheric temperature is 80 degrees F or above.

4. Perform cold weather concreting in conformance with ACI 306R and when the ambient atmospheric temperature is below 40 degrees F.

5. Concrete required to be moist cured shall remain moist for the entire duration of the cure. Repeated wetting and drying cycles of the curing process will not be allowed.

B. Curing Duration:

1. Start initial curing after placing and finishing concrete as soon as free moisture has disappeared from unformed concrete surfaces. Initial curing starts as soon as concrete achieves final set. Forms left tightly in place are considered as part of the curing system; keep forms in place a minimum of 72 hours (3 days).

2. Begin final curing procedures immediately following initial curing and before the concrete has dried. Continue final curing for at least 7 days and in accordance with ACI 301 procedures for a total curing period, initial plus final, of at least 10 days.

3. Avoid rapid drying at the end of the final curing period.

4. If protection is temporarily removed during the curing/protection period, the curing/protection period shall be extended by the amount of time lost (including time to bring concrete temperature back above 50 degrees F).

C. Curing Requirements:

1. Unformed Surfaces: Cover and cure entire surface of newly placed concrete immediately after completing finishing operations and water film has evaporated from surface or as soon as marring of concrete will not occur. Protect finished slabs from direct rays of the sun to prevent checking, crazing and plastic shrinkage.

2. Formed Surfaces: Minimize moisture loss for formed surfaces exposed to heating by the sun by keeping forms wet until safely removed. Keep surface continuously wet by warm water spray or warm water saturated fabric immediately following form removal unless otherwise permitted by the Engineer.

3. Other concrete: Moist cure by moisture-retaining cover curing, or by the use of curing compound.

D. Curing Methods: Contractor shall select from the following curing methods:

1. Water Curing: Use water curing for unformed surfaces. Continuously water cure all exposed concrete for the entire curing period. Continuous water curing shall not be used during winter construction; use sealing materials or membrane curing compound. Provide moisture curing by any of the following methods:

a. Keeping the surface of the concrete continuously wet by ponding or immersion.

b. Continuous water-fog spray or sprinkling.

c. Covering the concrete surface with curing mats, thoroughly saturating the mats with water, and keeping the mats continuously wet with sprinklers or porous hoses. Place curing mats so as to provide coverage of the concrete surfaces and edges, with a 4 inch lap over adjacent mats. Weight down the curing cover to maintain contact with the concrete surface.

2. Sealing Materials:

a. Use common sealing materials such as plastic film or waterproofing (kraft) paper.

b. Lap adjacent sheets a minimum of 12 inches. Seal edges with waterproof tape or adhesive. Use sheets of sufficient length to cover sides of concrete member.

c. Place sheet materials only on moist concrete surfaces. Wet concrete surface with fine water spray if the surface appears dry before placing sheet material.

d. The presence of moisture on concrete surfaces at all times during the prescribed curing period is proof of acceptable curing using sheet material.

3. Membrane Curing Compound:

a. Apply membrane-curing compound uniformly over concrete surface by means of roller or spray at a rate recommended by the curing compound manufacturer, but not less than 1 gallon per 150 square feet of surface area. Agitate curing material in supply container immediately before transfer to distributor and thoroughly agitate it during application for uniform consistency and dispersion of pigment

b. Do not use curing compounds on construction and expansion joints or on surfaces to receive concrete fills and toppings or other applications requiring positive bond.

c. Reapply membrane-curing compound to concrete surfaces that have been subjected to wetting within 3 hours after curing compound has been applied by method for initial application.

E. Protection from environmental conditions: Maintain the concrete temperature above 50 degrees F continuously throughout the curing period (10 days). Make arrangements before concrete placing for heating, covering, insulation or housing to maintain the specified temperature and moisture conditions continuously for the curing period.

1. When the atmospheric temperature is 80 degrees F and above, or during other climatic conditions which will cause too rapid drying of the concrete, make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture-retaining covering.

2. Protect the concrete continuously for the entire curing period (10 days).

3. Maintain concrete temperature as uniformly as possible and protect from rapid atmospheric temperature changes.

4. Avoid temperature changes in concrete that exceed 5 degrees F in any one hour and 50 degrees F in any 24-hour period.

F. Protection from physical injury: Protect concrete from physical disturbances such as shock and vibration during curing period. Protect finished concrete surfaces from damage by construction equipment, materials, curing procedures and rain or running water. Do not load concrete in such a manner as to overstress concrete.

G. Protection from Deicing Agents: Do not apply deicing chemicals to concrete.

3.07. FIELD QUALITY CONTROL

A. Hot Weather Requirements:

1. During hot weather, give proper attention to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete

temperatures or water evaporation in accordance with ACI 305R and the following.

2. When the weather is such that the temperature of the concrete as placed would exceed 90 degrees F, use ice or other means of cooling the concrete during mixing and transportation so that the temperature of the concrete as placed will not exceed 90 degrees F.

3. Take precautions when placing concrete during hot, dry weather to eliminate early setting of concrete. This includes protection of reinforcing from direct sunlight to prevent heating of reinforcing, placing concrete during cooler hours of the day, and the proper and timely application of specified curing methods.

4. There will be no additional reimbursement to the Contractor for costs incurred for placing concrete in hot weather.

5. Provide thermometers to indicate the ambient temperature and the temperature 2-inches inside the concrete surface. Thermometers, thermocouples or other means of measurement, acceptable to the Engineer, which provide readings for concrete 2-inches below the surface, may be used. Concrete temperatures shall be recorded at the beginning and end of each work day and shall continue for the entire curing duration.

B. Cold Weather Requirements:

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather in accordance with ACI 306R and the following.

2. When the temperature of the surrounding atmosphere is 40 degrees F or is likely to fall below this temperature, use heated mixing water not to exceed 140 degrees F. Do not allow the heated water to come in contact with the cement before the cement is added to the batch.

3. When placed in the forms during cold weather, maintain concrete temperature at not less than 55 degrees F. Materials shall be free from ice, snow, and frozen lumps before entering the mixer.

4. Maintain the air and the forms in contact with the concrete at temperatures above 40 degrees F for the first five days after placing, and above 35 degrees F for the remainder of the curing period. Provide thermometers to indicate the ambient temperature and the temperature 2 inches inside the concrete surface. Thermometers, thermocouples or other means of measurement, acceptable to the Engineer, which provide readings for concrete 2 inches below the surface, may

be used. Concrete temperatures shall be recorded at the beginning and end of each work day and shall continue for the entire curing duration.

5. Prior to concrete placement, the Contractor shall submit an example concrete temperature record for review. Refer to ACI 306R-10, Section 4.4 for additional guidance regarding temperature records.

6. At the conclusion of each placement's curing period, a concrete temperature record shall be submitted to the Engineer for review. This complete record shall be provided to the Engineer by 10:00 AM the morning following the last recorded temperature.

7. There will be no additional reimbursement made to the Contractor for costs incurred for placing concrete during cold weather.

C. Backfill and Flowfill Against Walls:

1. Do not place backfill or flowfill against walls until the structural concrete has obtained a compressive strength equal to the specified 28-day compressive strength unless otherwise approved in writing by the Engineer. Where backfill is to be placed on both sides of the wall, place the backfill uniformly on both sides.

2. Do not backfill the walls of structures that will be laterally restrained or supported by suspended slabs or slabs on grade until the slab is poured and the concrete has reached the specified compressive strength.

3. The Contractor may provide additional concrete testing at his expense to determine concrete strength.

D. Concrete Testing:

1. Concrete quality testing will be performed on the concrete by a Testing Agency retained by the Contractor. The Contractor shall be responsible for all concrete testing costs.

2. Field cured cylinders are required for the Project. The Contractor may also take additional laboratory cured cylinders for concrete quality testing.

3. Testing Agency Responsibilities:

   a. Perform sampling and curing of test specimen in accordance with ASTM C31.

   b. Take concrete samples at the point of placement to perform slump (per ASTM C143), air content (per ASTM C231), and temperature tests (per ASTM C1064) and for field control test specimens.

c. Testing Agency personnel will record truck and load number from the delivery batch ticket, the concrete placement location of each specimen, the date, concrete strength, slump, air content, and temperature.

d. The Testing Agency will cast a minimum of one “set” of 6 test specimens, each 6 inch diameter by 12 inch long cylinders.

e. The required quantity of test specimen “sets” shall be that from the following criteria which yields the highest number of “sets”.

(1) One set of specimens for each 50 cubic yards of each mix design of concrete.

(2) One set of specimens per placement.

(3) One set for each 1,000 square feet of surface area for slabs or walls.

f. Test cylinders in accordance with ASTM C39. Test one cylinder at 7 days for information; test three cylinders at 28 days for acceptance; and hold two reserve cylinders for verification. Strength acceptance will be based on the average of the strengths of the three cylinders tested at 28 days. If one cylinder of a 28-day test manifests evidence of improper sampling, molding, or testing, other than low strength, discard it and use one of the reserve cylinders for the test result.

g. The Testing Agency shall submit test reports of concrete testing specified above to the Contractor and to the Engineer.

4. Contractor Responsibilities:

a. Provide and maintain facilities for safe storage and proper curing of concrete test specimens on the project site, as required by ASTM C31.

b. Cure/protect field cylinders in the same manner as the corresponding portion of the structure.

5. The Contractor may take additional test cylinders and tests to establish early concrete strength at no additional expense to Maine DMR.

6. Concrete acceptance shall be based on the requirements of ACI 318.

7. Field cured cylinders conforming to ASTM C31 will be required to determine field compressive strength of concrete. Laboratory cured cylinders for concrete quality testing shall not be used for determining field compressive strength.

8. Concrete Coring:

a. When the concrete quality test specimen compression tests fail to be in compliance with the Contract Documents or when the Engineer detects deficiencies in the concrete, the Contractor will take concrete cores from the structure in conformance with ASTM C42 at locations determined by the Engineer. The concrete cores shall be at least two inches in diameter, with a length between 1.9 to 2.1 times the diameter.

b. Obtain at least three representative cores from each member or area of concrete that is considered potentially deficient.

c. Obtain additional cores to replace cores that show evidence of having been damaged subsequent to or during removal from the structure.

d. Concrete coring and core specimen labeling shall be performed in the presence of the Engineer. The Contractor shall submit cores to the Testing Agency for completion of cylinder compression tests in conformance with ASTM C39. The Testing Agency shall submit test strength test results of cores specified above to the Contractor and to the Engineer.

e. All costs associated with coring and testing of cores will be borne by the Contractor at no additional cost to Maine DMR.

f. Concrete not meeting the requirements of the Contract Documents shall be removed and replaced. All additional costs for concrete removal and replacement shall be borne by the Contractor at no additional cost to Maine DMR.

3.08. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 35 00

CONCRETE FINISHES

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section describes materials and methods of concrete finishes for cast-in-place concrete.

1.02. REFERENCES

A. American Concrete Institute (ACI):

1. 301: Specifications for Structural Concrete.

2. 302.1R: Construction of Concrete Floors.

3. 311.4R: Guide for Concrete Inspection.

1.03. SUBMITTALS

A. Submit shop drawings in accordance with 01 33 00.

1.04. QUALITY ASSURANCE

A. Prior to concrete construction, develop an outlined quality control program for concrete finishing.

PART 2 - PRODUCTS

2.01. CONCRETE REPAIR MATERIAL

A. Concrete repair material shall be in accordance with Section 03 01 30.

PART 3 - EXECUTION

3.01. CONCRETE FINISHES

A. Finish concrete surfaces in accordance with the following schedule:

Table 03 35 00-1	
Finish Designation	**Area Applied**
F-1	Beams, columns, and walls not exposed to water or view.
F-2	Walls, beams, and columns exposed to water.
F-3	Walls, beams, and columns of structures exposed to view and to 1 foot below water level or finished grade.
S-1	Slabs and concrete fill to be covered with concrete or grout.
S-2	Slabs and floors of structures exposed to view or which are water bearing.
S-3	Slabs and floors of structures which have foot traffic.
E-1	Exposed edges. EXCEPTION: edges normally covered with earth.
E-2	Top of walls, beams, and similar unformed surfaces with no foot traffic.
E-3	Top of walls and similar unformed surfaces with foot traffic (walkways, etc.)

1. Finish F-1: Repair defective concrete, fill depressions deeper than 1/2-inch, and fill tie holes.

2. Finish F-2: Repair defective concrete, remove fins, fill depressions 1/4-inch or deeper, and fill tie holes.

3. Finish F-3: In addition to Finish F-2, fill depressions and airholes with mortar. Dampen surfaces and then spread a slurry consisting of one part cement and one and one-half parts sand by damp loose volume, over the surface with clean burlap pads or sponge rubber floats. Remove any surplus by scraping and then rubbing with clean burlap.

4. Finish S-1: Screed to grade without special finish unless otherwise shown on the Contract Documents. Roughen and/or apply bonding agent where shown on the Contract Drawings.

5. Finish S-2: Smooth steel trowel finish.

6. Finish S-3: Finish without local depressions or high points and apply a final stiff bristle broom finish.

7. Finish E-1: Provide chamfer or beveled edges per Section 03 10 00.

8. Finish E-2: Strike smooth and float to an F-3 finish.

9. Finish E-3: Finish without local depressions or high points and apply a final stiff bristle broom finish.

B. Protect finished concrete surfaces from damage by construction equipment, materials, curing procedures and rain or running water.

3.02. FINISHING OF FORMED SURFACES

A. Cure surfaces until finishing and repairing are completed.

B. Perform finish work as soon as possible after forms are removed. Remove fins and irregularities by grinding or rubbing, fill depressions deeper than specified with mortar, and repair tie holes.

C. Conform to the requirements specified in Section 03 10 00 for tolerances for formed surfaces.

3.03. FINISHING OF UNFORMED SURFACES

A. Provide float finish then roughen the surface with stiff brushes or rakes before the final set for surfaces scheduled to receive concrete fills and toppings.

B. Provide steel-trowel finish to all top, horizontal and inclined surfaces not otherwise specified or indicated. This includes concrete fills and toppings and floors. Provide hand steel-trowel finish to all surfaces such as weirs or walls over which liquids will flow.

C. Provide broom finish to exterior walkways, exterior stairs, and concrete pads.

3.04. CONCRETE REPAIR

A. Surface Defects:

1. Do not repair defects until concrete has been reviewed by the Engineer. Coordinate repair of concrete surfaces with Section 03 01 30.

2. Repair defects including, air voids and bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, visible construction joints, fins, burrs, color and texture variations and other defects as determined by the Engineer.

Make concrete repairs with a polymer modified cementitious repair mortar in accordance with Section 03 01 30 to produce a concrete surface uniform in color and texture and free of all irregularities.

B. Crack Repair:

1. Repair concrete cracks in accordance with Section 03 01 30.

C. Tie-hole Repair:

1. Repair tie holes in accordance with Section 03 10 00.

3.05. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 60 00

GROUT

PART 1 - GENERAL

1.01. DESCRIPTION

A. Furnish all labor, materials, equipment, and incidentals required, and install grout complete as shown on the Drawings and as specified herein.

1.02. SUMMARY

A. Section Includes:

1. Material for grouting under bearing plates for columns or beams.

2. Materials for grouting under equipment.

3. Materials for miscellaneous grouting including but not limited to railing posts, equipment guides, etc.

4. Materials and equipment for grouting to fill existing pipe penetrations and seal new pipe penetrations through the concrete dam.

1.03. REFERENCE STANDARDS

A. American Petroleum Institute (API):

1. RP 686: Recommended Practice for Machinery Installation and Installation Design.

B. American Society for Testing and Materials (ASTM):

1. C33: Standard Specification for Concrete Aggregates.

2. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-In. Or [50-mm] Cube Specimens).

3. C595: Standard Specification for Blended Hydraulic Cements.

4. C827: Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixes.

5. C1107: Standard Specification for Packaged Dry, Hydraulic, Cement Grout (Non-shrink).

C. U.S. Army Corps of Engineers Standard (CRD):

1. C621: Corps of Engineers Specification for Non-shrink Grout.

1.04. SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Product Data:

1. Commercially manufactured non-shrink, non-metallic cementitious grout:

a. Include catalogue cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM standards, and Material Safety Data Sheet.

2. Cement Grout:

a. Include the type and brand of the cement, the gradation of the fine aggregate, product data on any proposed admixtures, and the proposed mix of the grout.

3. Concrete Grout:

a. Include data for concrete as delineated in Section 03 30 00. This includes the mix design, constituent quantities per cubic yard, and the water/cement ratio.

4. Bonding Agent:

a. Include catalogue cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM standards, and Material Safety Data Sheet.

C. Laboratory Test Reports:

1. Submit laboratory test data as required under Section 03 30 00 for concrete to be used as concrete grout.

D. Manufacturer's specifications and instructions for all admixtures, curing materials, adjustable inserts and non-shrink non-metallic grout. Manufacturer’s certification of compatibility of all admixtures.

E. Installation Plans:

1. Start-to-finish procedures for grout placement to fill/plug the existing pipe penetrations through the dam.

2. Start-to-finish procedures for grout placement to seal the anulus around the new pipe penetrations through the dam for the eel bypass piping and the fish bypass piping.

1.05. QUALITY ASSURANCE

A. Qualifications:

1. Grout manufacturer to have a minimum of 5 years experience in the production and use of the type of grout proposed for the Work.

B. Field Testing:

1. The Contractor shall employ an independent testing laboratory to perform field testing. The Contractor shall be responsible for all grout testing costs. Comply with the applicable ASTM Standards for testing.

2. Take compression test specimens from the first placement of each type of grout to ensure compliance with these Specifications.

a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at one, seven and 28 days.

1.06. RESPONSIBILITIES

A. The cost of laboratory tests on grout will be by the Contractor. Where test results show the grout to be defective, the Contractor shall pay for the tests, removal and replacement of defective work, and re-testing all at no cost to Maine DMR.

1.07. DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the jobsite in original, unopened packages, clearly labeled with the manufacturer's name, product identification, batch numbers, and printed instructions.

B. Store materials in accordance with the manufacturer's recommendations. Total storage time from date of manufacture to date of installation shall be limited to six months or the manufacturer's recommended storage time, whichever is less.

C. Reject material that becomes damp, lumpy or otherwise unacceptable and immediately remove from the site and replace with acceptable material at no cost to Maine DMR.

D. Deliver non-shrink cement based grouts as pre-blended, prepackaged mixes requiring only the addition of water.

1.08. SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall instruct the Contractor's personnel in the mixing, proper use and application of the non-shrink grout.

B. The manufacturer's representative shall provide written certification that materials have been mixed and applied properly and surfaces to receive these products have been prepared properly, all in conformance with manufacturer's requirements.

C. The on-site time required for the manufacturer's representative to achieve a successful installation shall be at the expense of the Contractor.

PART 2 - PRODUCTS

2.01. GENERAL

A. Provide materials produced by one manufacturer or supplier in order to provide standardization of appearance.

2.02. APPLICATION

A. Unless indicated otherwise, provide grouts as listed below:

Table 03 60 00-1	
Type of Grout	**Application**
Cement Grout	Surface repairs
Non-Shrink – Class I	Tanks and other non-motorized equipment.
	Filling block-out spaces for embedded items such as gate guide frames, etc. (Where placement time is less than 20 min.).
	Repair of holes and defects in concrete members that are not water bearing and not in contact with soil or other fill material.
Non-Shrink – Class II	Column base plates.
	Filling block-out spaces for embedded items such as gate guide frames, etc. (where placement time exceeds 20 min.)
	Filling the anulus between pipes and concrete cores.
	Filling/plugging concrete pipes (if grout is extended with aggregate per manufacturer's recommendations)
Concrete Grout	Toppings and concrete/grout fill.
	Filling/plugging concrete pipes

2.03. MATERIALS

A. Non-shrink Class I Grout:

1. Non-shrink Class I Grout shall have a minimum 28-day compressive strength of 5000 psi, when mixed at a fluid consistency.

2. Non-shrink Class I grout shall meet the requirements of ASTM C1107, Grade B or C, when mixed to fluid, flowable and plastic consistencies.

3. Products:

a. Sika Corp.; SikaGrout 212.

b. Master Builders, Inc.; Set Grout.

c. The Euclid Chemical Co.; Euco NS.

d. Or acceptable equivalent product.

B. Non-shrink Class II Grout:

1. Non-shrink grout shall be a high precision, fluid, extended working time grout. The minimum 28-day compressive strength shall be 7,500 psi, when mixed at a fluid consistency.

2. Grout shall have an extended working time of 30 minutes minimum when mixed to a fluid consistency as defined in ASTM C827 at temperature extremes of 45 to 90 degrees F in accordance with ASTM C1107.

3. Non-shrink grouts shall meet the requirements of ASTM C1107; Grade B or C when tested using the amount of water needed to achieve fluid consistency per ASTM C939.

4. The grout when tested shall not bleed or segregate at maximum allowed water.

5. Products:

a. Master Builders, Inc.; Masterflow 928.

b. The Euclid Chemical Co.; Hi-Flow Grout.

c. Sika Corp.; SikaGrout 212.

d. Or acceptable equivalent product.

C. Cement Grout:

1. Cement grouts shall be a mixture of one part Portland cement conforming to ASTM C595, Type IL and one to two parts sand conforming to ASTM C33 with sufficient water to place the grout. The water content shall be sufficient to impart workability to the grout, but not to the degree that it will allow the grout to flow.

2. Cement grout materials shall be as indicated in section 03 30 00, Cast-In-Place Concrete.

D. Concrete Grout:

1. Concrete grout shall conform to the requirements of Section 03 30 00 except as specified herein. Proportion with cement, coarse and fine aggregates, water,

water reducer, and air entraining agent to produce a mix having an average strength of 2,000 psi at 28 days. Coarse aggregate size shall be 3/8-inch maximum. Keep the W/C ratio as low as practical while still retaining sufficient workability.

E. Dry Pack Grout:

1. Make dry pack (to be packed or tamped in place) at no slump consistency.

2. When mixing the batch, add only enough water to the dry materials to produce a rather stiff mixture. Additions of water may be made in small increments until the desired consistency is obtained.

F. Grout for Filling Concrete Pipes:

1. Grout for filling concrete pipes shall be Concrete Grout or Non-shrink Class II Grout extended with aggregate per the manufacturer’s recommendations.

G. Non-epoxy Bonding Compound:

1. Provide non-epoxy bonding compound that is re-wetable for up to two weeks.

2. Products:

a. Larsen Products Corp.; Weldcrete.

b. Sta-Dry Manufacturing Corp.; Link.

c. Euclid Chemical Co.; Euco Weld.

d. Or acceptable equivalent product.

H. Vent Tubes

1. Vent tubes used during grouting operations, if necessary, shall be any appropriate type for the job.

I. Grout Tubes

1. Inside diameter of grout tubes shall be adequate to fully grout the entire space.

J. EQUIPMENT

1. Grouting Equipment

a. Grout Mixer: The grout mixer shall be a high-speed, high-shear, colloidal type grout mixer capable of continuous mechanical mixing that will produce uniform and thoroughly mixed grout which is free of lumps and undispersed cement.

2.04. CURING MATERIALS

A. Curing materials for cement grout shall be as specified in Specification 03 30 00 and as recommended by the manufacturer for prepackaged grouts.

PART 3 - EXECUTION

3.01. GENERAL

A. Grout shall not be placed until base concrete has attained its design strength, unless authorized otherwise by the Engineer.

B. Prepare surfaces for curing, and protection of cement grout in accordance with Section 03 30 00.

C. Shade the work sites from sunlight for at least 24 hours before and 48 hours after grouting.

D. Contact the grout manufacturer's representative for assistance on hot and cold weather grouting techniques and precautions if applicable.

3.02. PREPARATION

A. Clean concrete surfaces to receive grout free of ice, frost, dirt, grease, oil, curing compounds, laitance and paints, and free of all loose or unsound material or foreign matter that may affect the bond or performance of the grout.

B. Roughen concrete surfaces by chipping, sandblasting, or other mechanical means to ensure bond of the grout to the concrete. Remove loose or broken concrete. Irregular voids or projecting coarse aggregate need not be removed if they are sound, free of laitance and firmly embedded into the parent concrete.

C. Remove all loose rust, oil or other deleterious substances from metal embedments prior to the installation of the grout.

D. Wash concrete surfaces clean and keep them moist for at least 24 hours prior to the placement of cementitious or cement grout. Saturate by covering the concrete with a plastic sheet or using either a soaker hose, flooding the surface or other method acceptable to the Engineer. Remove visible water from the surface upon completion of the 24-hour period prior to grouting. Use an accepted adhesive bonding agent in lieu of surface saturation when accepted by the Engineer for each specific location of grout installation.

E. Construct grout forms or other leak proof containment. Forms shall be lined or coated with release agents recommended by the grout manufacturer.

F. Support equipment during alignment and installation of grout by shims, wedges, blocks, or other accepted means. Prevent the shims, wedges, and blocking devices from bonding to the grout by appropriate bond breaking coatings and remove them after grouting unless otherwise accepted by the Engineer.

3.03. INSTALLATION

A. Cement Grouts and Non-shrink Cementitious Grouts:

1. Mix in accordance with manufacturer's recommendations. Do not add cement, sand, pea gravel, or admixtures without prior approval by the grout manufacturer and the Engineer.

2. Avoid mixing by hand. Pre-wet the mixer and empty excess water. Add premeasured amount of water for mixing, followed by the grout. Begin with the minimum amount of water recommended by the manufacturer and then add the additional water required to obtain workability. However, do not exceed the manufacturer's maximum recommended water content.

3. Place grout into the designated areas in a manner that will avoid segregation or entrapment of air. Do not vibrate grout to release air or to consolidate the material. Placement should proceed in a manner that will ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary. Place grout rapidly and continuously to avoid cold joints. Do not place cement grouts in layers. Do not add additional water to the mix (re-temper) after initial stiffening.

4. When pressure grouting, grout from the lowest gravitational point; continue grouting until a steady stream of pure grout is seen coming out of the vent/relief hole and or from the de-air tube.

5. Just before the grout reaches its final set, cut back the grout to the substrate at a 45-degree angle from the lower edge of bearing plate unless otherwise accepted by the Engineer.

6. Begin curing immediately after form removal, cutback, and finishing. Keep grout moist and within its recommended placement temperature range for at least 24 hours after placement or longer if recommended by the manufacturer.

B. Concrete Grout:

1. Provide the underlying concrete surface with a broomed finish. Protect and keep the surface clean until placement of concrete grout.

2. Remove the debris and clean the surface of all dirt and other foreign materials.

3. Saturate the concrete surface for at least 24 hours prior to placement of the concrete grout. Remove excess water just prior to placement of the concrete grout. Place a cement slurry immediately ahead of the concrete grout so that the slurry is moist when the grout is placed. Work the slurry over the surface with a broom until it is coated with approximately 1/16- to 1/8-inch thick cement paste.

C. Dry Pack:

1. Dry pack consistency shall be such that the grout is plastic and moldable but will not flow.

2. The use of pneumatic pressure for dry-packed grouting requires acceptance of the Engineer.

3.04. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 03 70 00

MASS CONCRETE

PART 1 - GENERAL

1.01. DESCRIPTION

A. Produce a structure free of shrinkage cracks that would be a result of heat of hydration during the curing of large concrete cross-sections. Accomplish this through appropriate concrete mix design and management of concrete temperature and temperature differential.

B. Structural mass concrete requirements shall only apply to the large concrete sections of the fish lift concrete flume. Structural mass concrete for the fish lift concrete flume is defined as any concrete footing with a least dimension greater than 5 feet or other concrete placements with a least dimension greater than 5 feet.

C. Costs for complying with this specification shall be included in the cost for structural concrete.

1.02. REFERENCES

A. American Concrete Institute (ACI):

1. 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
2. 207.4R: Cooling and Insulating Systems for Mass Concrete.
3. 301: Specifications for Concrete Construction.
4. 305R: Hot Weather Concreting.

B. American Society for Testing and Materials (ASTM):

1. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
2. C595: Standard Specification for Blended Hydraulic Cements.
3. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
4. C989: Standard Specification for Slag Cement for Use in Concrete and Mortars.

1.03. SUBMITTALS

A. Submit the following in accordance with 01 33 00:

1. Layout for joints and mass concrete placements.

2. Thermal Control Plan.

3. Mass Concrete Mix Designs; including locations for use.

1.04. QUALITY ASSURANCE

A. Apply Class A cast-in-place structural concrete requirements in accordance with Section 03 30 00 with the modifications from this specification.

B. Unless otherwise indicated, materials, workmanship, and practices shall conform to ACI 301 "Specifications for Concrete Construction."

C. Contractor shall follow the procedures outlined in ACI 207.4R "Cooling and Insulating Systems for Mass Concrete" to formulate, implement, administer, and monitor a Temperature Control Plan, making adjustments as necessary to ensure compliance with the Contract Documents.

D. Hot weather concrete to conform to ACI 305R "Hot Weather Concreting".

PART 2 - PRODUCTS

2.01. MATERIALS

A. Cement:

1. Portland Cement, ASTM C595, Type IL.

2. Use only one brand of cement in any individual structure. Use no cement that has become damaged, partially set, lumpy, or caked. Reject the entire contents of the sack or container that contains such cement. Use no salvaged or reclaimed cement.

3. Maximum tricalcium aluminate shall not exceed 8 percent. The maximum percent alkalies shall not exceed 0.6 percent.

B. Fly Ash:

1. Class F fly ash conforming to ASTM C618 for chemical and physical properties.

2. Supplemental requirements in percent:

a. Maximum carbon content: 3 percent.

b. Maximum sulfur trioxide (SO3) content: 4 percent.

c. Maximum loss on ignition: 3 percent.

d. Maximum water requirement (as a percent of control): 100 percent.

C. Ground Granulated Blast-Furnace Slag (GGBFS)

1. Ground granulated blast-furnace slag shall conform to ASTM C989, Grade 120.

2.02. MIXES

A. Structural mass concrete mixes shall meet the minimum compressive strength, minimum cementitious content, and maximum water to cementitious ratio specified in Section 03 30 00 for Class A Concrete.

B. For mass concrete placements, provide a mix design with cement or a combination of cement with GGBFS and/or fly ash that achieves a maximum heat of hydration of 70 cal/gm at 7 days.

C. Combined GGBFS and fly ash content shall be no less than 20 percent, nor more than 40 percent of the total cementitious content by weight.

D. Aggregate size shall be 3-inches maximum for all mass concrete sections.

E. Air content as determined by ASTM C231 shall be 5 ±1½ percent for concrete using maximum aggregate size of 1½-inch or larger.

2.03. CONSTRUCTION

A. THERMAL CONTROL PLAN

1. Develop and submit a written Thermal Control Plan describing the procedures that will be used during the period of heat dissipation following concrete placement, so the temperature differential between the interior of the section and the outside surface of the section does not exceed the restrictions in Article 2.03-B. Submit the Thermal Control Plan at least 30 calendar days before the first intended structural mass concrete placement.

2. The Thermal Control Plan shall include, but not be limited to the following:

a. Based on the concrete mix design, determine by lab testing the adiabatic heat generation for the concrete mix to be used.

b. Proposed methods to achieve required concrete temperature and control concrete temperature differential through concrete mix design and construction practices for temperature control to prevent thermal cracking.

c. Provide information on the temperature sensing and recording equipment to be used and details of installation locations of the temperature probes for each planned mass concrete placement.

d. Monitoring Plan to control temperature gradient.

3. Compliance with this specification may result in long cooling times. Consider options to control heat of hydration that are compatible with their desired construction schedule and erection procedures.

4. Do not place concrete covered by this specification until the Thermal Control Plan has received written approval by the Engineer and equipment and materials necessary to facilitate the plan are on site and ready for use. Provide and install temperature sensing devices according to Article 2.03-B.

5. The location of construction joints shall be as approved in a submittal or as shown in the plans.

6. The Thermal Control Plan procedures may include, but are not limited to, the following:

a. Cooling component materials prior to addition to the mix to reduce the temperature of the concrete while in its plastic state.

b. Adding ice to the mix water.

c. Sprinkle coarse aggregate with water or wet the stockpile.

d. Controlling rate of concrete placement (low lifts).

e. Insulating the forms and the surface of the concrete to prevent temperature differential.

f. Placing concrete at times of day when the ambient temperature is lowest (in summer) or highest (in winter).

g. Other acceptable methods that may be developed by the Contractor and approved in writing by the Engineer.

B. THERMAL CONTROL

1. Concrete Temperature Limits

a. Maximum concrete temperature at time of placement shall not exceed 70 degrees F and shall not be less than 40 degrees F. The maximum concrete temperature during the period of heat dissipation shall not exceed 160 degrees F.

2. Temperature Differential Restrictions

a. The temperature differential between the interior of the section and the outside surface of the section shall not exceed the limit in the following table:

Hours after Placement	Maximum Temperature Differential (Degrees F)
0-24	20
24-48	30
48-72	40
>72	50

b. Thermal control of each placement shall be maintained until the temperature of the interior is within 50 degrees F of the average outside air temperature. The average outside air temperature shall be determined by averaging the daily high and low temperatures over the preceding seven calendar days.

3. Temperature Sensing and Recording

a. For each placement of structural mass concrete, two temperature sensors shall be installed at each of the following locations (for a total of ten temperature sensors):

(1) Center of the placement,

(2) midpoint of the side which is the shortest distance from the center (locate 2 inches to 3 inches from the surface),

(3) midpoint of the top surface (locate 2 inches to 3 inches from the surface),

(4) corner of the placement which is furthest distance from the center (locate 2 inches to 3 inches from the surface), and

(5) air temperature.

b. The purpose for two sensors at each location is to provide a primary and secondary backup.

c. Temperatures shall be electronically recorded automatically by an approved recorder furnished by the Contractor and shall be capable of continuously recording a minimum of one reading per hour for the duration of the mass concrete temperature monitoring period.

d. Sensors and recorder shall be accurate to within +/- 2 degrees F in the temperature range of 32 degrees F to 212 degrees F.

e. Provide a backup temperature sensing system, which shall include both backup temperature sensors and backup temperature readout device. Back-up system is intended to be used to complete the monitoring of a placement should the primary system fail. Primary system shall be repaired or replaced before the commencement of the next placement.

C. PRODUCTION CONCRETE

1. Only use approved mixes for production concrete.

2. The Engineer shall review the installation of monitoring devices and verify the process for recording temperature data is effective for the first placement of each size and type of mass concrete component.

3. Recorded temperature data shall be reviewed at intervals of no greater than 4 hours. Recording of temperature data shall begin when the mass concrete placement is complete and shall continue until the maximum temperature differential (not maximum temperature) is reached and a decreasing temperature differential is confirmed as defined in the Thermal Control Plan.

4. If conditions change, such as a drop in the ambient temperature or a change in insulation which would result in an increase in the temperature differential, the recording of temperature data shall be resumed.

5. A copy of all recorded temperature data shall be furnished to the Engineer as they are determined, and a final report shall be furnished within 3 days of completion of monitoring of each element.

6. If the temperature differential within any structural mass concrete placement exceeds the limits in Article 2.03-B, immediate corrective action as directed by the Engineer shall be taken, future placement of structural mass concrete will be suspended, and a revised Thermal Control Plan shall be submitted to the Engineer for approval. Do not resume placement of mass concrete without written approval from the Engineer.

7. Based on the analyses and test results, a determination of corrective action will be made by the Engineer which may include, but not be limited to, price adjustment, epoxy injection of thermal cracks, a combination of both, or removal of the non-complying concrete.

END OF SECTION

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SECTION 05 12 00

STRUCTURAL STEEL

PART 1 - GENERAL

1.01. DESCRIPTION:

A. The term "Structural Steel" is used as defined in accordance with the AISC Code of Standard Practice.

B. Provide structural steel as specified and as shown in the Contract Drawings.

C. Furnish labor, materials, equipment, and incidentals necessary to install the products and items specified.

1.02. REFERENCES:

A. American Institute of Steel Construction (AISC):

1. 303: Code of Standard Practice for Steel Buildings and Bridges.
2. 325: Manual of Steel Construction.
3. 326: Structural Steel Detailing Manual.
4. 348: Specification for Structural Joints using ASTM A325 or A490 Bolts.
5. 360: Specification for Structural Steel Buildings.

B. American Society for Testing and Materials International (ASTM):

1. A6: Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
2. A36: Standard Specification for Carbon Structural Steel.
3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
4. A108: Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
5. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
6. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

7. A307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.

8. A384: Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

9. A385: Practice for Providing High Quality Zinc Coatings (Hot-Dip).

10. A500: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

11. A563: Standard Specification for Carbon and Alloy Steel Nuts.

12. A572: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

13. A780: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

14. A992: Standard Specification for Steel for Structural Shapes for Use in Building Framing.

15. B695: Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

16. F436: Standard Specification for Hardened Steel Washers.

17. F844: Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.

18. F959: Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series.

19. F1554: Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield.

20. F3125: Standard Specification for High Strength Structural Bolts, Steel, and Alloy Steel, Heat Treated 120 ksi and 150 ksi Minimum Tensile Strength.

C. American Welding Society (AWS):

1. A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination.

2. D1.1: Structural Welding Code – Steel

D. Occupational Safety and Health Administration (OSHA):

1. Safety and Health Standards for the Construction Industry, 29 CFR 1926 Subpart R Safety Standards for Steel Erection.

E. Governing Building Code:

1. International Building Code (IBC).

F. Research Council on Structural Connections (RCSC):

1. Specification for Structural Joints Using High-Strength Bolts

1.03. DESIGN CRITERIA:

A. Unless otherwise noted on the Contract Drawings, design connections for ASTM F3125, Grade A325 bolts, bearing-type connection with threads included in shear plane.

1.04. SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Submit shop drawings and product data showing materials of construction and details of installation for all items furnished under this Section. Shop drawings shall show sizes of members, method of assembly, and connection to other members.

2. Submit complete information necessary for the fabrication of each component and part of the structural systems and steel framing. Include the following:

a. Member size and length.

b. Bill of materials.

c. Material specifications.

d. Bolt hole size and bolt size.

e. Cuts, copes, and bevels.

f. Piece marks for field assembly.

g. Detail of each connection or typical connection.

h. Splices.

i. Identify coating system for each component.

3. Submit erection drawings showing complete information necessary for the erection of each component part of the structural steel framing. Include the following:

    a. Dimensions for alignment and elevations of each member.

    b. Location of members and attachments by match-marking of piece numbers.

    c. Type and location of each field connection.

    d. Number of welded studs on each member.

    e. Detail of each field connection or typical connection.

    f. Anchor blots and setting plans.

4. Do not develop shop drawings by using reproductions of Contract Drawings. Identify each shop drawing detail by Contract Drawing detail title.

5. Indicate both shop and field welding and the required nondestructive testing by welding symbols and nondestructive testing symbols as shown in the latest edition of AWS A2.4. Include reference to the Contractor's approved welding procedure specification (WPS) numbers and nondestructive testing (NDT) procedure numbers.

    a. Fully explain special conditions with notes or details.

    b. Welding symbols for groove welds shall indicate the groove depth required to obtain the specified effective throat thickness for the welding process and position of welding to be used.

    c. The details of groove welds, joints, and preparation of base material shall be referenced to prequalified joints specified in AWS Figures 3.2 through 3.11 and shall clearly distinguish between complete joint penetration and partial joint penetration.

    d. Fillet weld symbols shall indicate required weld size to obtain the specified effective throat thickness and effective length. For fillet weld lengths not specified provide a continuous weld.

    e. Submit plans for preheating and welding in the shop and in the field. Preheating shall consider section thickness, base metal chemistry, restraint, and ambient temperature.

B. Evidence of Conformity to Specifications:

1. Submit certified mill test reports containing results of chemical and mechanical test as specified by ASTM A6 for the following material:

    a. Structural steel shapes.

    b. Structural steel bars.

    c. Structural steel plates.

2. In addition to the certified mill test reports, the fabricator shall provide an affidavit stating that the structural steel furnished meets the requirements of ASTM specification for the grade furnished. Test any of the members not represented by certified mill test reports by the testing laboratory in accordance with ASTM specification for chemical and physical properties. The Contractor is responsible for the cost of sampling and testing.

3. Documented visual, magnetic particle, and other non-destructive inspection of welds as applicable.

4. Certified or record copies of all shop and field measurements and test data.

5. Submit manufacturer's certification and test data that the following items furnished conform to the following specifications:

    a. High-strength bolts including nuts and washers. Provide Connection type N per the AISC handbook unless otherwise noted in the drawings.

    b. Welded Studs: ASTM A108, stud base qualification requirements in accordance with AWS Code Section 7.6.

6. Proposed Substitutions: Submit for review in sketch form prior to submittal of shop drawings substitutions of members or modifications of details, if proposed by the Contractor. Submit in sketch form for review corrections for inaccuracy that result in a change from the structural drawing or final shop drawing details. Make such substitutions or corrections only when permitted by the Engineer.

7. Qualification test reports bearing witness certification by an independent testing laboratory for each welder, welding operator and tacker to be employed in the work.

1.05. QUALITY ASSURANCE:

A. Provide structural steel in accordance with AISC Standard for Structural Steel Buildings and the Code of Standard Practice for Steel Buildings and Bridges, unless otherwise specified herein.

B. Use connections shown or, if not shown, select connections to support half the AISC maximum uniform load for the indicated beam size and span.

C. Steel fabricator shall have 5 years' experience minimum in structural steel fabrications.

D. Steel erector shall have 5 years' experience minimum in structural steel erection.

E. Welding Qualification and Certification:

1. Submit the welding processes, procedures, and equipment description to be used in each phase of the Work for approval prior to commencement of any welding. All equipment shall conform to the requirements for arc-welding equipment as set forth in AWS D1.1.

2. Furnish written welding procedure specifications (WPS) with procedure qualification records (PQR) of pre-qualified welding procedure specifications for welds in conformance with AWS D1.1 not less than 10 calendar days prior to beginning welding.

3. Each welder, welding operator, and tack welder shall be certified by test to perform type of work required in conformance with AWS D1.1. Welder Qualification Test Record (WQTR) shall be submitted to the Engineer not less than 10 calendar days prior to beginning welding for welders performing both shop and field work.

F. Tolerances:

1. Maintain tolerances conforming to AISC Code of Standard Practice and the Contract Documents.

2. Fabrication tolerances, refer to Paragraph 2.04.B.

3. Permissible variation tolerances conforming to ASTM A6.

4. Means and methods for maintaining tolerance requirements shall be included in the Quality Control Plan.

G. While being assembled, each steel item of the steel assembly shall be checked for dimensions, tolerances, accuracy of alignment workmanship and compliance to the approved drawings. Any deficiencies and deviations from the contract and/or approved drawings shall be corrected. All instruments and devices required during the inspection for the examination, measurement or testing of the steel assemblies shall be provided and calibrated by the manufacturer.

H. Steel:

1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material, except mill scale that will withstand vigorous wire brushing may remain. Perform no welding when base metal is lower than 50 degrees F.

2. Qualify welding operators in accordance with AWS D1.1. Qualification tests shall be run by a recognized testing laboratory acceptable to the Engineer at the Contractor's expense.

1.06. DELIVERY, STORAGE AND HANDLING:

A. Insofar as practical, shop-assemble items specified herein. Package, ship, and tag unassembled materials in a manner that will protect materials from damage and will facilitate identification and field assembly.

B. Load structural members in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.

C. Protect structural steel members and packaged materials from corrosion and deterioration. Store material in a dry area.

D. Support materials stored outdoors above ground surfaces on wood runners and protected with acceptable effective and durable covers.

E. Do not place materials on the structure in a manner that might cause distortion or damage to the members or the supporting structures. Repair or replace damaged materials or structures as recommended by the Engineer.

F. Protect painted coatings and hot-dip galvanized finishes from damage due to metal banding and rough handling. Use padded slings and straps.

G. Upon receipt of fabricated assemblies at the job site, the Contractor and the Engineer shall inspect for shipping damage. The Contractor shall replace or repair damaged items at no cost to the Maine DMR.

1.07. FIELD MEASUREMENTS:

A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.

B. Review the Contract Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

1.08. DRAWING REVIEW

A. The Contractor shall review the Contract Drawings, and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 - MATERIALS

2.01. STRUCTURAL STEEL:

A.	W Shapes:	ASTM A992
B.	C, M, S and HP Shapes:	ASTM A572, Grade 50
C.	Angles, Plates and Bars:	ASTM A36
D.	Structural Tube Members (HSS):	ASTM A500, Grade C
E.	Steel Pipe:	ASTM A53, Grade B
F.	Hot-Dip Galvanized Carbon Steel:	ASTM A123.

2.02. BOLTS, ANCHOR BOLTS, AND ACCESSORIES:

A.	High-Strength Bolts:	ASTM F3125, Grade A325
B.	Nuts for ASTM F3125 Bolts:	ASTM A563, Grade C
C.	Steel Washers:	ASTM F436
D.	Direct Tension Indicators (DTIs), Washers:	ASTM F959
E.	Bolts (Ordinary Use):	ASTM A307, Grade A
F.	Nuts for ASTM A307 Bolts:	ASTM A563, Grade A
G.	Plain Unhardened Steel Washers:	ASTM F844
H.	Steel Anchor Bolts:	ASTM F1554, Grade
I.	Welded Studs:	ASTM A108, Grade 1015 or 1020

J. All steel hardware (bolts, nuts, and washers) shall be hot dip galvanized per ASTM A153.

2.03. WELDING:

A. Class E70XX electrodes.

B. Provide equipment for welding, electrodes, welding wire and fluxes capable of producing indicated welds when used by certified welders under AWS welding procedures. Provide welding materials that comply with the requirements of AWS D1.1 - Structural Welding Code.

C. Where carbon steel materials are subject to welding, use only Prequalified Base Metal-Filler Metal Combinations shown in Table 3.1 of AWS D1.1.

D. Welding rods shall be compatible with both materials affected by the welding.

E. Welding rods shall be stored in a manner to keep dry.

2.04. FABRICATION:

A. Fabricate each element and connection as indicated on the fabrication shop drawings accepted by the Engineer. Fabricate and shop assemble work to the greatest extent practical in conformance with following publications:

1. AISC Manual of Steel Construction.

2. AISC Specification for Structural Joints.

3. AISC Detailing Manual.

4. AWS Structural Welding Code.

5. RCSC Specification for Structural Joints Using High-Strength Bolts.

B. Fabrication Tolerances:

1. All dimensions shall have an implied tolerance of +/- 1/16-inch. Overall tolerance of single or multiple dimensions is not accumulative, i.e., features and locations shall be exactly within +/- 1/16-inch.

2. The above tolerances are subject to variation with approval from the Engineer.

C. Connections and Workmanship:

1. Fabricate details and connection assemblies in accordance with the Contract Drawings and Specifications, with projecting corners clipped and filler pieces welded flush.

2. Fit the work together in fabrication shop and deliver complete or in parts, ready to be set in-place or assembled in the field.

3. Provide work true to detail with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture free from defects impairing strength or durability.

4. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.

5. Provide 1/8" minimum chamfer or 1/16" minimum radius at the edges for all of the plates.

6. Provide full cross section bearing on milled ends of columns and bearing stiffeners.

7. Shop Inspection: While being assembled, the fabricator shall check each item for dimensions, tolerances, accuracy of alignment, workmanship, and compliance with reviewed shop drawings. Any deficiencies and deviations shall be corrected.

8. Bolting:

    a. Connect members with ASTM F3125, Grade A325 high strength bolts unless otherwise specified or shown on contract drawings. Provide clean-cut holes without torn or ragged edges and remove outside burrs.

    b. Provide high-strength bolted construction assembly in accordance with AISC and RCSC Specifications for Structural Joints. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Free joint surfaces burs and foreign materials. Score hot-dipped galvanized contact surfaces with a wire brush or blasted prior to assembly. Grinding of surfaces is not permitted. If the thickness of the material is not greater than the normal diameter of the bolt plus 1/8 inch, the holes may be punched. If the thickness of the material is greater than the normal diameter of the bolt plus 1/8 inch, drill it full size or subpunched 1/16 inch smaller than the bolt diameter and reamed to full size. Provide holes for work to be secured to structural steel framing and for the passage of work through steel framing members. Provide threaded nuts, threaded units, or other items welded to framing, which receive other work. Provide normal bolt hole diameters not more than 1/16 inch in excess of the normal bolt diameter unless otherwise specified in contract drawings. Provide required slotted or oversize bolt holes as specified in the AISC Specification for Structural Joints Section 3.3. Tighten each bolt to provide the minimum tensions specified in the AISC Specification for Structural Joints for the size and grade of bolts used. Tighten bolts in accordance with the manufacturer's specifications. Pre-installation verification testing shall be performed as specified in 7.2 in the AISC Specification for Structural Joints.

c. Provide anchor rods with washer and heavy hex nuts. Provide hot-dip galvanized anchor rods, washers and heavy hex nuts with galvanized steel.

d. Direct Tension Indicators (DTIs), washers are permitted to be used for high-strength bolted connections. DTIs shall not be used as a substitute for hardened steel washers.

e. Hardened steel washers or plate washers are required to be used on 'over-sized' or slotted holes, even when DTIs are used. In such cases, DTIs should not be placed directly on top of the 'over-sized' or slotted holes, but on top of the hardened washer covering the 'over-sized' or slotted hole.

9. Welding:

a. Unless otherwise authorized or specified, welding shall be by the electric arc-welding process, using a method which excludes the atmosphere from the molten metal, conforming to the applicable provisions of AWS D1.1.

b. Welding procedure specifications (WPS) supported with procedure qualification test and records (PQR) shall be submitted for review by the Engineer prior to commencement of the respective welding.

c. Preheating shall be per AWS D1.1. At a minimum, preheating shall be performed for all steel sections with a thickness of 3/4” or greater. The minimum preheat temperature shall be established at a distance that is at least equal to the thickness of the thickest member, but not less than 3 inches in all directions from the point of welding. The steel temperature should be checked to verify that the minimum preheat temperature has been established just prior to initiating the arc for each pass.

d. All welding operators, including tack welders and machine welders, shall be qualified and, as necessary, prequalified for the work to be done in accordance with American Welding Society's Standard Qualification Procedure AWS D1.1. The Contractor shall certify by name the qualified welding operators to the Engineer with a Welder Qualification Test Record (WQTR).

e. All seams and joints shall be seal welded, in addition to what is specified on the drawings or unless noted otherwise.

f. Grind exposed edges of welds to 1/8-inch minimum radius. Grind burrs, jagged edges, and surface defects smooth.

g. Prepare welds and adjacent areas so there is:

(1) No undercutting or reverse ridges on weld bead.

(2) No weld spatter on or adjacent to weld or other area to be painted or coated.

(3) No sharp peaks or ridges along weld bead.

h. Weld inspections shall be completed in accordance with the requirements of AWS D1.1.

(1) The Contractor shall clean all welds of scale, slag, weld spatter and any other foreign matter in preparation for inspection and shall ascertain that all welding conforms to the requirements of the Specifications and detail drawings as to size, length, location, and positioning of members prior to welding.

(2) All welds shall be inspected 100 percent of their length by non-destructive testing as specified herein or approved by the Engineer. Unless noted otherwise, the choice of using the magnetic particle, liquid penetrant, or other approved method, shall be made by the Contractor, with approval of the Engineer. The aim of the testing shall be to provide, in each instance, the best possible determination of the soundness of the welded joint and shall be indicated on the shop drawings submitted for approval. Non-destructive test reports for the welds shall be submitted to the Engineer.

(3) All non-destructive testing (NDT) and inspections shall be performed only by experienced personnel.

(4) All defective welds shall be repaired in accordance with AWS D1.1. Sections of welds that have been inspected as specified and are found to be unacceptable shall be removed by mechanical means, oxygen-flame gouging, or other approved method and shall be rewelded and re-inspected using the same procedure as originally used, or other procedure as approved by the Engineer.

2.05. SHOP PAINTING:

A. Apply shop prime coat to structural steel, except to members or portions of members to be embedded in concrete, surfaces and edges to be field welded, and galvanized surfaces, unless otherwise specified. Provide surface preparation as described for the specified coating system.

B. Immediately after surface preparation, apply primer. Use painting methods that will result in full coverage of joints, corners, edges, and exposed surfaces.

C. Refer to Section 09 90 00.

2.06. GALVANIZE:

A. Provide hot-dip galvanizing in conformance with ASTM A123, Grade 100 to steel indicated or specified to be galvanize coated.

B. Provide hot-dip galvanizing, in conformance with ASTM A153, to bolts, nuts and washers that will be used with galvanized steel.

C. Direct tension indicating washers shall be mechanically galvanized in conformance with ASTM B695 Class 55.

D. Complete fabrication and prepare surfaces of steel by removing weld spatter, flux, residue, burrs and metal surface defects before galvanizing. Clean weldments with power wire brush prior to galvanizing.

E. Provide steel dipped into solution of zinc chloride plus ammonium chloride immediately prior to galvanizing.

F. Tap bolt nuts after hot-dip galvanizing in conformance with ASTM A563.

G. Inspect galvanized material for compliance with these specifications. Mark the material with a clearly visible stamp indicating the name of the galvanizer, the ASTM number and the weight of zinc coating in ounces per square foot.

2.07. GALVANIZE TOUCH-UP:

A. Refer to Specification Section 09 90 00 Painting and Coating.

PART 3 - EXECUTION

3.01. ERECTION OF STRUCTURAL STEEL:

A. Conform to the IBC and referenced AISC standards. Brace and secure work until permanent connections are completed. Provide accessories and fasteners to secure the work in place whether or not shown or specified. Comply with OSHA requirements.

B. Erect structural steel with qualified, experienced personnel. Plan and lay out steel to require minimum of cutting. Erect work plumb, square, and true to line and level and in precise positions. Provide temporary bracing and guys to counteract loads and stresses to which structure may be subjected, including those due to erection equipment and its operation. Do not encumber premises with material or equipment.

C. Splice members only where shown or specified. On exposed welded connections, remove erection bolts, fill holes with plug welds, and grind smooth at exposed surfaces. Comply with AISC specifications for bearing, adequacy of temporary connections, alignment, and the removal of paint on surfaces adjacent to field welds. Do not enlarge holes in members by burning or the use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to place bolts. Do not use gas-cutting torches in the field for correcting fabrication errors in the structural framing.

D. Erect, plumb, level, and align each individual member within the tolerance defined in Section 7 and Commentary of the AISC Code of Standard Practice, allowing for weld shrinkage during erection for assurance that the end product is within specified tolerance. Establish and maintain the building line for use in plumbing the exterior columns.

3.02. DAMAGED MEMBERS:

A. During erection, straighten or replace members that are bent, twisted, or damaged. If heating is required in straightening, perform heating by methods that ensure uniform temperature throughout entire member. When required by the Engineer, remove members that are impaired strength and replace with new members at no additional cost to Maine DMR.

3.03. MISFITS AT BOLTED CONNECTIONS:

A. Immediately notify the Engineer where misfits in erection bolting are encountered. Submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

B. Do not enlarge incorrectly sized or misaligned holes in members by burning or by the use of drift pins. Notify the Engineer immediately and submit a proposed method of remedy for review by the Engineer.

3.04. ANCHOR BOLTS:

A. Install anchor bolts by using templates, setting drawings, and instructions provided by the fabricator. Verify positions of bolts prior to delivery of steel; report errors or deviation for adjustment. After anchor bolts have been embedded, protect threads by applying grease and by having the nuts screwed on until the metalwork is installed.

3.05. COLUMN BASEPLATES AND BEARING PLATES:

A. Set columns with base plates attached and bearing plates for beams and similar structural members to their proper alignment and elevation using shim packs. Set loose column bases level to their proper alignment and elevation by use of shim packs or as shown in the contract drawings. Tighten anchor bolts after members have been positioned and plumbed. Do not remove protruding wedges, shims, or other leveling devices but cut off flush with the baseplate prior to packing with grout.

3.06. CONNECTIONS:

A. Securely bolt members to maintain steel in position during field welding and final bolting and accommodate dead loads, wind, and erection stresses.

B. Tighten high-strength bolted connections in accordance with AISC Specification for Structural Joints using ASTM F3125, Grade A325 bolts and manufacturer's specifications.

C. Direct Tension Indicators (DTIs), washers shall be oriented with the protrusions bearing against the hardened bearing surface of the bolt head, or nut, or against a hardened flat washer.

1. Snug the steel plies, in as many steps as necessary, to bring the steel into firm contact as required by AISC/RCSC, without compressing the DTI below the Job Inspection Gap.

2. If the DTI is compressed below the Job inspection Gap, during the snugging operation, remove and replace the DTI.

3. After snugging, apply enough torque to compress the DTI until the residual gap is less than the Job Inspection Gap.

D. Perform shop-welded construction in accordance with AWS D1.1 Sections 2 through 6, whichever is applicable. Use only welded joints deemed as being prequalified in accordance with AWS Code Section 4, which are selected from AWS Code Figures 3.2 through 3.11.

E. Do not reuse galvanized high-strength bolts, nuts and washers.

3.07. SHOP/FIELD QUALITY CONTROL:

A. The Contractor shall notify the Engineer of readiness for items under this Section to be inspected a minimum of 10 working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

3.08. CLEAN-UP:

A. Upon completion of the work, remove surplus materials, rubbish, and debris resulting from the operations, including disused equipment and implements of service, and leave the entire structure and site, insofar as the work of this section is concerned, in a neat, clean condition.

3.09. CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 50 00

MISCELLANEOUS METAL

PART 1 - GENERAL

1.01. DESCRIPTION:

A. This section includes metal fabrications not specifically included in other Sections and required for completion of work as shown on Contract Drawings and in accordance with Contract Documents.

B. Furnish labor, materials, equipment and incidentals necessary to install the products specified.

1.02. REFERENCES:

A. American Society for Testing and Materials International (ASTM):

1. A6: General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.

2. A36: Standard Specification for Carbon Structural Steel.

3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

4. A108: Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.

5. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

6. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

7. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

8. A240: Standard Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels.

9. A276: Standard Specification for Stainless Steel Bars and Shapes.

10. A312: Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.

11. A307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.

12. A500: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

13. A563: Standard Specification for Carbon and Alloy Steel Nuts.

14. A992: Standard Specification for Structural Shapes.

15. B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

16. B308: Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

17. F436: Standard Specification for Hardened Steel Washers.

18. F593: Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

19. F594: Standard Specification for Stainless Steel Nuts.

20. F844: Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.

21. F879: Standard Specification for Stainless Steel Socket Button and Flat Countersunk Head Cap Screws.

22. F1554: Standard Specification of Anchor Bolts, steel, 36, 55 and 105-ksi Yield Strength.

23. F3125: Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

B. American Institute of Steel Construction (AISC):

1. Specification for Structural Steel Buildings, Fifteenth Edition (AISC 360-16).

2. Design Guide 27: Structural Stainless Steel (Second Edition).

C. American Welding Society (AWS):

1. A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination.

2. D1.2: Structural Welding Code – Aluminum.

3. D1.6: Structural Welding Code – Stainless Steel.

D. International Code Council - Evaluation Services (ICC-ES):

1. ICC-ES Acceptance Criteria 308: Post-installed Adhesive Anchors in Concrete Elements.

1.03. SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Submit shop drawings and product data showing materials of construction and details of installation for all items furnished under this Section. Shop drawings shall show sizes of members, method of assembly, anchorage, and connection to other members.

2. Submit certified copies of mill test reports on each steel, stainless steel, and aluminum proposed for use showing the physical properties and chemical analysis.

3. Do not develop shop drawings by using reproductions of the Contract Drawings. Identify each shop drawing detail by Contract Drawing detail title.

4. Product Data:

a. Manufacturer's catalog sheets on pre-manufactured items.

b. Manufacturer's catalog sheets on wire rope accessories, adhesive anchors, and undercut anchors.

B. Proposed Substitutions:

1. The Contractor shall identify any proposed product substitutions a minimum of 30 calendar days prior to fabrication. Product substitutions are only allowed when permitted by the Engineer. Submittals shall be in accordance with Specification 01 33 00.

2. Submit for review in sketch form prior to submittal of shop drawings substitutions of members or modifications of details. Submit in sketch form for review corrections for inaccuracy that result in a change from the structural drawing or final shop drawing details. Make such substitutions or corrections only when permitted by the Engineer. Submittals shall be in accordance with Specification 01 33 00.

1.04. QUALITY ASSURANCE:

A. Tolerances:

1. While being assembled, each item of the assembly shall be checked for dimensions, tolerances, accuracy of alignment workmanship and compliance to the approved drawings. Any deficiencies and deviations from the contract and/or approved drawings shall be corrected. All instruments and devices required during the inspection for the examination, measurement or testing of the assemblies shall be provided and calibrated by the manufacturer.

2. Fabrication tolerances, refer to Paragraph 2.05.A.

B. Steel:

1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material, except mill scale that will withstand vigorous wire brushing may remain. Perform no welding when base metal is lower than 50 degrees F.

2. Qualify welding operators in accordance with AWS D1.1. Qualification tests shall be run by a recognized testing laboratory acceptable to the Engineer at Contractor's expense.

C. Stainless Steel:

1. Surfaces to be welded shall be free from foreign material. Perform no welding when base metal temperature is lower than 50 degrees F.

2. Qualify welding operators in accordance with AWS D1.6.

D. Aluminum:

1. Weld with gas metal arc (GMA) or gas tungsten arc (GTA) processes in accordance with AWS.

E. Adhesive Anchors:

1. Adhesive anchor installers shall be trained and certified by the anchor manufacturer.

F. Undercut Concrete Anchors:

1. Undercut concrete anchor installers shall be trained and certified by the anchor manufacturer.

1.05. DELIVERY STORAGE AND HANDLING:

A. Insofar as practical, factory assemble items specified herein. Package, ship and tag unassembled materials in a manner that will protect materials from damage and will facilitate identification and field assembly.

B. Package stainless steel items in a manner to provide protection from contact with carbon steel.

C. Protect hot-dip galvanized finishes from damage due to metal banding and rough handling. Use padded slings and straps.

D. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.

E. Upon receipt of fabricated assemblies at the job site, the Contractor and the Engineer shall inspect for shipping damage. The Contractor shall replace damaged items at no cost to Maine DMR.

F. Store fabricated items in a dry area, not in direct contact with ground.

1.06. FIELD MEASUREMENTS:

A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.

B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01. MISCELLANEOUS METAL SHAPES, CASTINGS, BOLTS AND ACCESSORIES:

A. Structural Steel Shapes:

1.	W Shapes:	ASTM A992
2.	S, C and MC Shapes:	ASTM A36
3.	L Shapes:	ASTM A36
4.	HSS Square and Rectangular Shapes:	ASTM A500, Grade C, 50 ksi
5.	HSS Round Shapes:	ASTM A500, Grade B, 42 ksi
6.	Pipe Shapes:	ASTM A53, Grade B, 35 ksi

7. Plates and Bars: ASTM A36

8. Steel Sheets: ASTM A36

B. Steel Bolts, Anchor Bolts, and Accessories:

1. High-Strength Bolts: ASTM F3125, Grade A325

2. Nuts for ASTM F3125 Bolts: ASTM A563, Grade C

3. Steel Washers: ASTM F436

4. Bolts (Ordinary Use): ASTM A307, Grade A

5. Nuts for ASTM A307 Bolts: ASTM A563, Grade A

6. Plain Unhardened Steel Washers: ASTM F844

7. Pins with Recessed Nuts: ASTM A108, Grade 50 (minimum)

8. Steel Anchor Bolts: ASTM F1554, Grade 36

9. Welded Studs: ASTM A108, Grade 1015 or 1020

10. All steel hardware (bolts, nuts, and washers) shall be hot dip galvanized per ASTM A153.

C. Stainless Steel Shapes:

1. All Uses: AISI, Type 304

2. For Welding: AISI, Type 304L

3. Shapes and Bars: ASTM A276, Type 304L

4. Plate, Sheet and Strip: ASTM A240

5. Pipe: ASTM A312, Type 304L

D. Stainless Steel Bolts, Anchor Bolts, and Accessories:

1. Stainless Steel Headed Bolts: ASTM F593, Type 304, CW1

2. Stainless Steel Threaded Rods: ASTM A193, Type 304, Grade B8, Class 1

3. Stainless Steel Flat Countersunk Head Cap Screws: ASTM F879, Type 304

4. Stainless Steel Nuts: ASTM F594, Hex, CW1 or CW2, Type 304

5. Stainless Steel Washers: ASTM A240

E. Aluminum Shapes:

1. Structural Shapes: ASTM B308, Alloy 6061-T6

2. Aluminum Sheet and Plate: ASTM B209, Alloy 6061-T6

F. Wire Rope and Accessories:

1. 3/4" diameter, 6x19 class, galvanized steel wire rope

2. Heavy duty galvanized steel thimble

3. 1-1/4" x 18" jaw and jaw galvanized steel turnbuckle

4. 1" galvanized steel anchor shackle - bolt type

5. 3/4" galvanized steel drop forged wire rope clip

2.02. POST INSTALLED ANCHORS:

A. Adhesive Anchors (Typical Unless Noted Otherwise):

1. Products:

a. Hilti Corporation, HIT-RE 500 V3

b. Or approved equal.

2. General:

a. Adhesive anchors supporting stainless steel members shall be Stainless Steel Type 304.

b. Adhesive anchors supporting galvanized steel members shall be hot-dipped galvanized.

B. High Strength Stainless Steel Undercut Concrete Anchors (Only Where Shown on the Drawings):

1. Products:

a. Williams Form Engineering Corporation, S-9 Undercut Anchors - Stainless Steel ASTM A193, Type 316, Grade B8M, Class II.

b. Or approved equal.

2.03. GRATING SUPPORT ANGLES AND FRAMING:

A. Provide galvanized steel support angles embedded in concrete. Angles shall be 1/4-inch thick, inside depth of support angle shall equal depth of bearing bar, inside length of support angle leg shall equal depth of grating, but not less than 2 inches. Provide 1 inch by 1/4-inch by 8 inches long bent anchor bars or 3/8-inch diameter by 6 inch headed anchor studs welded to backs of angles at 18 inches on center.

2.04. STRAP ANCHORS AND STUD ANCHORS:

A. Provide anchors for frames, curbs, sills, and other metal fabrications anchored into concrete. Fabricate anchors from strap iron, bent to shape, or of weldable studs, welded to backs of members. Where size and spacing not noted, provide 1 inch by 1/4-inch strap anchors or 3/4-inch diameter studs. Space concrete anchors at 3 feet on center.

B. Where anchors and plates or clips are to be built in for attachment of later Work, provide bolts in plates or clips, welded to back, with threaded ends extended.

C. For attaching Work to concrete where anchors or inserts cannot be built in, provide concrete anchors or machine bolts and screws.

2.05. FABRICATION:

A. Fabrication Tolerances:

1. All dimensions shall have an implied tolerance of +/- 1/16-inch. Overall tolerance of single or multiple dimensions are not accumulative, i.e., features and locations shall be exactly within +/- 1/16-inch.

2. The above tolerances are subject to variation with approval from the Engineer.

B. Connections and Workmanship:

1. Fabricate details and connection assemblies in accordance with Contract Drawings and Specifications, with projecting corners clipped and filler pieces welded flush.

2. Fit work together in fabrication shop and deliver complete or in parts, ready to be set in-place or assembled in field.

3. Provide work true to detail; with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture free from defects impairing strength or durability.

4. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.

5. Provide castings of uniform quality, free from blowholes, porosity, hard spots, shrinkage distortion; smooth and well cleaned by shot blasting.

6. Welding:

   a. Provide rigid and continuous welds or spot welded as specified and as shown on Contract Drawings. Dress the face of welds flush and smooth. Close fit exposed joints and locate where least conspicuous.

   b. Weld shop connections and bolt or field weld connections, unless otherwise specified.

   c. Grind exposed edges of welds to 1/8-inch minimum radius. Grind burrs, jagged edges, and surface defects smooth.

   d. Prepare welds and adjacent areas so there is:

      (1) No undercutting or reverse ridges on weld bead.

      (2) No weld spatter on or adjacent to weld or other area to be painted or coated.

      (3) No sharp peaks or ridges along weld bead.

7. Bolting:

   a. Use bolts of lengths required so bolts do not project more than 1/4-inch beyond face of nut. Do not use washers for steel connections unless specified. Provide hexagonal head bolts with hexagonal nuts.

   b. Provide holes required for connection of adjacent or adjoining work wherever noted on Drawings. Locate holes for bolting equipment to supports to tolerance of +/- 1/16-inch of dimensions indicated.

C. Shop Assembly, Inspection, and Matchmarking:

1. Shop Assembly: Fabricator shall completely shop assemble the hopper and other large assemblies. This shop assembly will be witnessed by the Engineer.

2. Shop Inspection: While being assembled, the fabricator shall check each item for dimensions, tolerances, accuracy of alignment, workmanship, and compliance with reviewed shop drawings. Any deficiencies and deviations shall be corrected.

3. Matchmarking: Before disassembling, the fabricator shall clearly matchmark all parts. Matchmark diagrams for field installation shall be prepared and submitted to the Engineer.

PART 3 - EXECUTION

3.01. EXAMINATION:

A. Upon receipt of material at job site, inspect all materials for shipping damage. Replace damaged items at no cost to Maine DMR.

B. Examine supports for size, layout and alignment.

C. Correct defects considered detrimental to proper installation.

3.02. INSTALLATION:

A. Provide items such as bolts, shims, blocks, nuts, washers, and wedging pieces to complete installation.

B. Erect to lines and levels, plumb and true, and in correct relation to adjoining Work. Secure parts using concealed connections when practicable.

C. Plumb and true vertical members to tolerance of +/- 1/8 inch in 10 feet. Level horizontal members to tolerance of +/- 1/8 inch in 10 feet.

D. Use steel bolts to connect structural steel members.

E. Use stainless steel bolts to connect stainless steel members and structural aluminum members.

F. Tighten ASTM A307 steel bolts and stainless steel bolts to snug tight.

G. Apply an anti-seize compound on all stainless steel fasteners to prevent galling.

H. Hand tighten the turnbuckles for the wire rope connections.

I. Anchor Bolts, Adhesive Anchors, and Undercut Concrete Anchors:

1. Preset anchor bolts using templates. Do not use adhesive anchors in place of anchor bolts.

2. After anchor bolts are embedded, protect projecting threads by applying grease and having the nuts installed until the time of installation of equipment or metalwork.

3. Do not install adhesive anchors until concrete has reached specified minimum compressive strength.

4. Install undercut concrete anchors in accordance with anchor manufacturer recommendation. Embedment depth of anchor shall be as recommended by the anchor manufacturer, but not less than as shown on the Contract Drawings.

J. Weld headed anchor studs in accordance with manufacturer's recommendations.

K. Do not place new holes or enlarge unfair holes by use of cutting torch.

3.03. PAINTING, REPAIR, AND PROTECTION:

A. Painting:

1. Paint steel except members or portions of members to be embedded in concrete, surfaces and edges to be field welded, and galvanized surfaces, unless otherwise specified.

2. Refer to Section 09 90 00.

B. Galvanize:

1. Provide hot-dip galvanizing in conformance with ASTM A123, Grade 100 to steel indicated or specified to be galvanize coated.

2. Provide hot-dip galvanizing, in conformance with ASTM A153, to bolts, nuts and washers that will be used with galvanized steel.

C. Galvanize Touch-up:

1. Refer to Section 09 90 00 Painting and Coating.

D. Protection:

1. Protect aluminum from contact with dissimilar metals, concrete, or mortar. Paint aluminum in contact with concrete. Under no circumstances shall aluminum contact concrete or dissimilar metal.

2. Refer to Section 09 90 00 Painting and Coating.

3.04. CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 05 51 10

STEEL STAIRS AND LADDERS

PART 1 - GENERAL

1.01. DESCRIPTION:

A. Provide steel stairs and ladders as indicated and in compliance with Contract Documents.

1. Section Includes:

a. Steel stair frame of structural sections, with open risers.

b. Open grate stair treads, and landings.

c. Vertical steel ladders.

d. Inclined steel (ship) ladders.

1.02. REFERENCES:

A. American Institute of Steel Construction (AISC):

1. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

B. American Society for Testing and Materials International (ASTM):

1. A36/A36M: Standard Specification for Carbon Structural Steel.

2. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

3. A153/A153M: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

4. A325: Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

C. American Welding Society (AWS):

1. A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination.

2. D1.1: Structural Welding Code - Steel.

3. D5.5: Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding.

D. Code of Federal Regulations (CFR):

1. 28 CFR Part 36, Appendix A – ADAAG: Americans with Disabilities Act Accessibility Guidelines.

2. 41 CFR Part 101, Subpart 101-19.6, Appendix A – UFAS: Uniform Federal Accessibility Standards.

E. National Association of Architectural Metal Manufacturers (NAAMM):

1. AMP 510: Metal Stairs Manual.

2. MBG 531: Metal Bar Grating Manual.

F. Occupational Safety and Health Administration (OSHA):

1. 29 CFR, Part 1910, Occupational Safety and Health Standards.

1.03. PERFORMANCE/DESIGN CRITERIA:

A. Stairs and ladders shall conform to OSHA.

B. Stairs and inclined (ship) ladders shall be designed to withstand a minimum uniform live load of 100 psf or a concentrated live load of 300 pounds applied on an area at any point along the element.

C. Vertical ladders shall be designed to withstand a minimum of two loads of 250 pounds each, concentrated between any two consecutive attachments. The number and spacing of additional loads shall be in accordance with the anticipated usage of the ladder. Individual steps or rungs shall be designed to support a load of 250 pounds applied at any point.

1.04. SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Shop drawings showing clearly the location, size and details of all members.

2. Indicate materials, dimensions, connection attachments, anchorage, size and type of fasteners, holes, finishes, and accessories for steel stairs and ladders.

3. Reference materials of construction by ASTM designation and grade.

4. Indicate welds including length and size of all shop and field welds by symbols conforming to AWS standards.

5. Letter certifying that stairs and ladders are designed and detailed to meet the requirements of standards, building codes, specifications and design criteria herein described.

B. Product Data:

1. Manufacturer’s catalog sheets on pre-manufactured items.

2. Manufacturer’s specifications, load tables, anchor details, and installation details.

1.05. QUALITY ASSURANCE:

A. Obtain field measurements and elevations prior to preparation of shop drawings and fabrication.

B. Welding Qualification and Certification:

1. Furnish written welding procedure for all welds in conformance with AWS Structural Welding Code.

2. Use welders, tackers and welding operators certified by test to perform type of work required in conformance with AWS Structural Welding Code. Maintain current test records certified by an independent testing laboratory.

3. Maintain duplicate qualification and certification records at the job site readily available for examination.

1.06. DELIVERY, STORAGE AND HANDLING:

A. Identify and match-mark materials, items and fabrications, for installation and field assembly.

B. Deliver items to jobsite as complete units, wherever practicable, ready for installation or erection, with anchors, hangers, fasteners and miscellaneous metal items required for installation.

C. Carefully handle and store materials, protected from weather, corrosion and other damage.

D. Store off the ground on suitable supports.

E. Accept material on site. Inspect for damage.

F. Do not incorporate damaged materials in the work.

PART 2 - PRODUCTS

2.01. MATERIALS:

A. Steel materials and welding electrodes per Section 05 12 00.

B. Metal Railings per Section 05 52 00.

2.02. FABRICATION:

A. General:

1. Fabricate true to shape, size and tolerances as indicated and specified.

2. Straighten work bent by shearing or punching.

3. Dress exposed edges and ends of metal smooth, with no sharp edges and with corners slightly rounded.

4. Provide sufficient quantity and size of anchors for the proper fastening of the work.

5. Fabricate details and connection assemblies in accordance with drawings, with projecting corners clipped and filler pieces welded flush.

6. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, for fabrication and erection.

7. Use connections of type and design required by forces to be resisted, and to provide secure fastening.

8. Fit work together in fabrication shop and deliver complete, or in parts, ready to be set in place.

B. Welding:

1. Grind exposed edges of welds to a 1/8 inch minimum radius. Grind burrs, jagged edges and surface defects smooth.

2. Prepare welds and adjacent areas such that there is no undercutting or reverse ridges on the weld bead and no sharp peaks or ridges along the weld bead.

3. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.

C. Bolting:

1. Provide galvanized stud bolts, nuts and washers for fastening galvanized steel material.

2. Provide holes required for the connection of adjacent or adjoining work wherever noted on drawings. Locate holes for bolting to supports to a tolerance of 1/16-inch of exact dimensions indicated.

D. Finishes:

1. Hot dip galvanize fabricated stairs and ladders in accordance with ASTM A123.

2.03. GRATING STAIR:

A. Rectangular Bar Grating Treads:

1. Provide stair treads of the same type and bar spacing as grating specified.

2. Provide serrated top surface of bearing bars.

3. Provide minimum 2-1/2 inch by 3/16-inch carrier end plates welded to stair treads and punched for bolting to stringers.

4. Provide 1-1/4 inch abrasive nosings.

5. Manufacturers:

a. IKG Borden Metal Products Co.; Grating Type B.

b. Ohio Gratings, Inc.; Grating Type SG Series.

c. McNichols Co.; Grating Type B.

2.04. VERTICAL LADDERS:

A. Fabricate ladders as shown in the drawings. Ladders shall be welded steel construction and galvanized after fabrication.

B. Minimum diameter of rungs shall be 3/4-inch. The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder.

C. The minimum clear length of rungs or cleats shall be 16 inches.

D. For through ladders, the steps or rungs are omitted from the extensions, and the side rails shall be spaced further apart or flared provide not less than 24 inches and not more than 30 inches of clearance. Grab bars extend 42 inches above the access level or landing platforms served by the ladder.

E. Coat rungs with coarse grain nonskid epoxy coating No. 6901T44 as supplied by McMaster-Carr Supply Company or acceptable equivalent product. Color of coating shall be gray. Apply nonskid coating per manufacturer's recommendations.

2.05. INCLINED STEEL (SHIP) LADDERS WITH BUILD-IN HANDRAILS:

A. Ladders shall be welded steel construction and galvanized after fabrication. Clear width of stair treads shall be 24 inches. Provide 1-1/2 inch diameter handrails. Stairs shall be angled at 70 degrees from the horizontal. Coat rungs with coarse grain nonskid epoxy coating No. 6901T44 as supplied by McMaster-Carr Supply Company, or acceptable equivalent product. Color of coating shall be gray. Apply nonskid coating per manufacturer's recommendations.

PART 3 - EXECUTION

3.01. GENERAL:

A. Set and secure in place as indicated. Where bolted connections are used, draw together and draw nuts tightly. Use bolts of lengths required so that they do not project more than 1/4-inch beyond face of nut. Provide hexagonal head bolts with hexagonal nuts.

B. Locate anchors and anchor bolts and build into connecting work.

C. Install stairs and ladders in accordance with shop drawings.

3.02. STEEL STAIRS:

A. Provide galvanized structural steel angles, struts, rod hangers, closure plates, and brackets indicated.

3.03. LADDERS:

A. Grind welds smooth where required. Provide assemblies with no sharp or rough surface.

3.04. REPAIR OF GALVANIZED SURFACES:

A. Refer to Section 09 90 00 Painting and Coating.

3.05. CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00

END OF SECTION

SECTION 05 52 00

METAL RAILINGS

PART 1 - GENERAL

1.01. DESCRIPTION

A. Design, furnish and install railing systems, including connectors, fasteners, and system required accessories.

1.02. REFERENCES

A. American Society of Civil Engineers (ASCE)

1. 7: Minimum Design Loads for Buildings and Other Structures.

B. American Society for Testing and Materials (ASTM)

1. A36/A36M: Standard Specification for Carbon Structural Steel.

2. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. A123/A123M: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

5. E935: Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.

6. E985: Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.

C. American Welding Society (AWS)

1. C5.6: Recommended Practices for Gas Metal Arc Welding.

2. D1.1-1.17: Structural Welding Code.

D. International Code Council

1. IBC: International Building Code.

E. National Ornamental & Miscellaneous Metals Association (NOMMA)

1. Guideline 1: Joint Finishes.

2. Metal Rail Manual.

1.03. PERFORMANCE/DESIGN CRITERIA

A. Design and provide handrail and guardrail system to meet IBC, OSHA, and the criteria specified herein. Railing shall be capable of withstanding the following loads without exceeding design allowable stress of materials for handrails, railing anchors and connections.

1. Top rail

a. Uniform load of 50 pounds per foot applied in any direction.

b. Concentrated load of 200 pounds applied in any direction at any point.

c. Uniform and concentrated loads above need not be assumed to act concurrently.

2. Intermediate rails

a. Uniform load of 50 pounds per foot applied in any direction. Uniform load above need not be assumed to act concurrently with loads acting on top rail.

3. Interior Handrail at stairs

a. Uniform load of 50 pounds per foot applied in any direction.

b. Concentrated load of 200 pounds applied in any direction at any point.

c. Installed at both sides of stairs. Handrail must be continuous, and the gripping surface should have minimal obstruction.

B. Thermal movements: Provide adequate expansion within the system to allow for thermal expansion and contraction caused by a temperature change of 100 degrees F to -20 degrees F without buckling or warping, opening of joints, overstressing of components, failure of connections and other detrimental effects.

C. Control of corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.04. SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 30 00.

1. Show fabrication and installation of handrails and railings assembled from standard components. Include plans, elevations, component details, materials, finishes, connection and joining methods, and mounting details to adjoining work.

2. Provide plan, elevation, and section views for all railing. Identify location and type indicated. Identify expansion joint locations.

3. Submit calculations or test data demonstrating that the railing system will resist the loads specified herein and OSHA. Calculations shall be stamped by a Professional Civil or Structural Engineer.

B. Product Data

1. Manufacture’s literature.

2. Assembly and installation instructions.

C. Certificates

1. Welders' Certificates: Certifying welders employed on the Work, verifying AWS qualification within the previous 12 months.

2. Submit certification that the railing system is in compliance with OSHA.

D. Operation and Maintenance Data

1. Manufacturer’s instructions describing procedures for maintaining including cleaning materials, application methods, and precautions as to use of materials which may be detrimental to finish when improperly used.

1.05. QUALITY ASSURANCE

A. Obtain field measurements prior to preparation of shop drawings and fabrication.

B. Handrails provided shall be end products of one manufacturer/fabricator to achieve standardization for appearance, maintenance and replacement.

C. Manufacturer/fabricator shall have a minimum of five years of experience specializing in manufacturing products specified in this Section.

D. Welding Qualification and Certification

1. Furnish written welding procedure for all welds in conformance with AWS Structural Welding Code.

2. Each welder, tacker and welding operator shall be certified by test to perform type of work required in conformance with AWS Structural Welding Code. Testing shall be conducted, and witnessed by an independent testing laboratory.

3. Maintain duplicate qualification and certification records at the job site readily available for examination.

1.06. DELIVERY STORAGE AND HANDLING

A. Deliver, store and handle materials in manner preventing damage to finished surfaces.

B. Store materials in a dry, well ventilated, weather tight place away from uncured concrete.

1.07. SITE CONDITIONS

A. Field verify measurements prior to fabrication and indicate measurements in shop drawings.

PART 2 - PRODUCTS

2.01. STEEL RAILING SYSTEM AND COMPONENTS

A. Material: 1-1/2 inch diameter minimum, steel welded or seamless pipe minimum Schedule 40 meeting requirements of ASTM A53.

B. Railings at open-side construction shall consist of three members with posts. Locate intermediate rails between top rail and finish floor as indicated on Drawings.

C. Provide 1/4-inch thick by 4-inch high or “S” type toe plate except on stairs and where concrete curb provided. Provide 1/4-inch clearance above floor level. Expansion joint in toe plate location to match railing joint location.

D. Fabrication

1. Angles, offsets, other changes in alignment, and joining of posts and rails shall be made with welded or mechanically fastened connections. Miter and weld joints by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Run top rails continuously over post.

2. Rail splices shall be butted and reinforced by tight fitting interior sleeve not less than 6 inch long.

3. Fabricate wall railings with wall brackets for intermediate support and wall return fittings at ends. Brackets and end fittings shall be of cast or formed metal of same material and finish as supported rails and shall be of proper size to

provide 3 inch clear space between wall and railing. Provide wall brackets not more than 5 feet on center.

4. Provide expansion joint splices at 30 feet maximum spacing, with slip joint internal sleeve extending minimum of 4 inch beyond each side of joint. Weld to one side only. Locate within 12 inch of posts.

5. Provide expansion joint splices at changes in support condition (transition from steel to concrete, concrete expansion joints, etc.).

6. Space posts as shown on Drawings. Where spacing is not shown, space posts not more than 5 feet on center. Erect posts plumb in each direction.

7. Fabricate joints which will be exposed to weather so as to exclude water. Provide weep holes at the lowest possible point on all railing system posts.

E. Railings at walls shall be single member

1. Support wall rails on brackets spaced not more than 5 feet on center and at each end of rail. Cantilevered extensions are not allowed.

F. Anchorage

1. Railings at Concrete: Provide concrete anchorage for posts by means of base flange welded to post and anchored to concrete with minimum of 4 concrete anchors.

2. For posts set on stair stringers or platform beams, provide base flange or bracket welded to post and bolted to stringer/beam with minimum of two 5/8-inch bolts, or weld post to stringer/beam.

G. Removable Railings: Install removable railing units free-standing in close fitting galvanized pipe sleeves, unattached to other railing units and adjoining work unless otherwise indicated.

H. Safety Chains:

1. 1/4-inch galvanized steel link chain with spring actuated stainless steel clasp capable of withstanding 250 pound horizontal force.

2. Locate safety chains as shown on Drawings and near equipment locations per Woodland Pulp and the Engineer.

3. Number of chains shall match number of horizontal rails.

4. Chain drape shall not exceed 3 inch.

I. Finishes:

1. Hot dip galvanized welded pipe railing in accordance with ASTM A123.

PART 3 - EXECUTION

3.01. INSTALLATION

A. Install as shown on Drawings and accepted shop drawings.

B. Set posts plumb and aligned in each direction to within 1/4-inch in 12 feet.

C. Set rails horizontal or parallel to rake of steps to within 1/4 inch in 12 feet.

D. Fit exposed connections together to form tight, hairline joints.

E. Provide anchorage devices and fasteners for securing handrails and railings and for transferring loads structures.

F. Provide mechanical joints for permanently connecting railing components at nonwelded connections.

3.02. CLEANING

A. Wash thoroughly using clean water and soap, rinse with clean water.

B. Do not use acid solution, steel wool or other harsh abrasive.

C. When stain remains after washing, remove finish and restore in accordance with manufacturer's instructions.

3.03. PROTECTION

A. Protect surfaces of completed installations to prevent damage during construction activities.

3.04. REPAIR GALVANIZED SURFACES

A. Refer to Section 09 90 00 Painting and Coating.

3.05. CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 05 53 00

METAL GRATING

PART 1 - GENERAL

1.01. DESCRIPTION:

A. Provide metal grating as indicated and in compliance with Contract Documents.

B. This section includes:

1. Galvanized Steel Grating.

2. Stainless Steel Grating.

C. Furnish all labor, materials, equipment and incidentals necessary to install the products specified.

1.02. REFERENCES:

A. American Society for Testing and Materials International (ASTM):

1. A6: General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.

2. A36: Standard Specification for Carbon Structural Steel.

3. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

5. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

6. A240: Standard Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels.

7. A276: Standard Specification for Stainless Steel Bars and Shapes.

8. A307: Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

B. American Welding Society (AWS):

1. D1.1: Structural Welding Code.

2. D1.6: Structural Welding Code - Stainless Steel.

C. National Association of Architectural Metal Manufacturers (NAAMM):

1. MBG 531: Metal Bar Grating Manual.

2. MBG 533: Welding Specifications for Fabrication of Steel, Aluminum and Stainless Bar Grating.

1.03. DESIGN CRITERIA:

A. Grating

1. Provide grating of minimum depth shown on contract drawings, not exceeding manufacturer’s maximum recommended span, and meeting the following load and deflection criteria.

a. 100 psf uniform live load or 300 pound concentrated live load, whichever produces maximum stress.

b. L/360 maximum deflection under uniform live load of 100 psf.

1.04. SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 30 00.

1. Detail shop drawings indicating:

a. Dimensions.

b. Sectional assembly.

c. Location and identification mark. Include material and indicate if serrated or not.

d. Connections and fastening methods.

e. Size and location of supporting frames required.

f. Materials of construction.

g. Installation instructions.

2. Catalog data and design tables showing limits for span length and deflection under load.

1.05. QUALITY ASSURANCE:

A. Obtain field measurements prior to preparation of shop drawings and fabrication.

B. All welding shall be in accordance with AWS

1.06. DELIVERY STORAGE AND HANDLING:

A. Store to avoid damage.

B. Protect hot-dip galvanized finishes from damage due to metal banding and rough handling. Use padded slings and straps.

C. Avoid stainless steel in contact with dissimilar metals.

D. Remove material that has become damaged as to be unfit for use.

E. Identify and match-mark all materials, items, and fabrications for installation and field assembly.

1.07. FIELD MEASUREMENTS:

A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.

B. Review the Contract Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

PART 2 - PRODUCTS

2.01. GALVANIZED STEEL GRATING:

A. Manufacturers:

1. IKG Borden Metal Products Co.; Type B.

2. Ohio Gratings, Inc.; Type W Series.

3. McNichols Co.; GW Series.

B. Provide steel grating material conforming to ASTM A36.

C. Provide 3/16-inch thick bearing bars spaced 1-3/16-inch center to center with cross bars pressure locked on 4 inch centers, or as otherwise shown on the Contract Drawings.

D. Provide serrated top surface of bearing bars for grating used for walkways and platforms. Provide smooth (non-serrated) surfaces for grating subjected to flow/water.

E. Fabricate in standard size sections where possible.

F. Apply bearing bar banding at ends of grating sections and where two or more bearing bars are cut.

G. Anchor grating to support members using saddle clips or removable fasteners.

H. Hot dip galvanize steel grating after fabrication in accordance with ASTM A123.

2.02. STAINLESS STEEL GRATING:

A. Manufacturers:

1. IKG Borden Metal Products Co.; Type B.

2. Ohio Gratings, Inc.; SGSS Series.

3. McNichols Co.; GW Series.

B. Provide type 304/304L stainless steel grating material.

C. Provide 3/16-inch thick bearing bars spaced 1-3/16-inch center to center with cross bars pressure locked on 4 inch centers, or as otherwise shown on the Contract Drawings.

D. Provide smooth (non-serrated) surfaces.

E. Fabricate in standard size sections where possible.

F. Apply bearing bar banding at ends of grating sections and at fixture or pipe openings where two or more bearing bars are cut.

G. Anchor grating to support members using stainless steel saddle clips or removable fasteners.

PART 3 - EXECUTION

3.01. EXAMINATION:

A. Upon receipt of material at job site, inspect all materials for shipping damage. Damaged items shall be replaced at no cost to Maine DMR.

B. Examine supports for size, layout and alignment. Surface shall be free of debris.

C. Correct defects considered detrimental to proper installation.

3.02. METAL GRATING INSTALLATION:

A. Install and make connections in accordance with accepted submittals and manufacturer’s written instructions.

B. Install materials accurately in location and elevation, level and plumb. Field fabricate as necessary for accurate fit.

C. Coordinate and furnish anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete construction.

3.03. REPAIR GALVANIZED SURFACES

A. Refer to Section 09 90 00 Painting and Coating.

3.04. CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 06 50 00

STRUCTURAL FRP

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section includes materials, installation, and testing of structural FRP elements, plates, and members.

1.02 REFERENCES:

A. American Society for Testing and Materials International (ASTM):

1. C177: Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
2. D570: Standard Test Method for Water Absorption of Plastics.
3. D635: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
4. D638: Standard Test Method for Tensile Properties of Plastics.
5. D695: Standard Test Method for Compressive Properties of Rigid Plastics.
6. D696: Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer.
7. D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
8. D792: Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
9. D2344: Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates.
10. D2563: Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts.
11. D2583: Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

12. E84: Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS:

A. Submit shop drawings in accordance with the General Conditions and Section 01 33 00.

B. Submit product data for the FRP material.

C. Submit fabrication drawings of FRP structural elements, plates, and members. Include plans, elevations, sections, details, dimensions, bolt hole locations, and bills of material.

PART 2 - MATERIALS

2.01 MANUFACTURERS:

A. Structural FRP materials shall be manufactured by Strongwell, Fibergrate, or approved equivalent.

2.02 FRP:

A. Manufacture FRP products using a pultrusion process utilizing a vinyl ester resin with flame-retardant and UV inhibitor additives. A synthetic surface veil shall be the outermost layer covering the exterior surface. The FRP shapes and plates shall achieve a flame spread of 25 or less in accordance with ASTM E84.

B. After fabrication, seal cut ends, holes, and abrasions of FRP shapes and plates with a compatible resin coating to prevent intrusion of moisture.

C. Exposed surfaces shall be smooth and true to form.

D. Construct structural shapes from a vinyl ester resin with fire-retardant additives to meet Class 1 flame rating of ASTM E84 and meet the self-extinguishing requirements of ASTM D635. Structural shapes shall contain a UV inhibitor.

E. Structural FRP member composition shall consist of a glass-fiber-reinforced vinyl ester resin matrix, approximately 50% resin-to-glass ratio. A synthetic surface veil shall be the outermost layer covering the exterior surfaces. Continuous glass strand rovings shall be used internally for longitudinal strength. Continuous strand glass mats shall be used internally for transverse strength.

F. Color of FRP material shall be gray. The color shall be achieved using pigmented resin. Do not paint.

G. The applicable minimum mechanical properties are summarized in the following table.

Fiberglass Pultruded Material Properties Minimum Ultimate Coupon Properties		
Material Properties for Pultruded Fiberglass Structural Shapes	**ASTM Test Method**	**Value**
Ultimate tensile stress in longitudinal direction (psi)	D638	30,000
Ultimate compressive stress in longitudinal direction (psi)	D695	30,000
Ultimate flexural stress in longitudinal direction (psi)	D790	30,000
Ultimate short beam shear in longitudinal direction (psi)	D2344	4,500
Ultimate tensile stress in transverse direction (psi)	D638	7,000
Ultimate compressive stress in transverse direction (psi)	D695	15,000
Ultimate flexural stress in transverse direction (psi)	D790	10,000
Density (lb/cubic inch)	D792	0.060 to 0.070
Water absorption (24-h immersion)	D570	0.60 max, % by weight
Barcol hardness	D2583	45
Coefficient of thermal expansion (in/in/°C)	D696	8×10^{-6}
Coefficient of thermal expansion (in/in/°F)	D696	4.4×10^{-6}
Thermal conductivity (Btu-in/ft^2/hr/°F)	C177	4
Flame-Retardant Properties	**ASTM Test Method**	**Value**
Flammability test	D635	Self-extinguishing
Surface burning characteristics	E84	25 maximum
Flammability class	UL 94	VO
Temperature index	UL 94	130°C

2.03 FASTENERS:

A. Fasteners shall be galvanized steel for connecting to carbon steel and Type 304 stainless steel for all other applications.

B. Provide washer under each nut and bolthead.

PART 3 - EXECUTION

3.01 INSPECTION:

A. After delivery to the site, check FRP items for cracks, holes, and other characteristics listed in ASTM D2563, Table I. Remove any FRP item not complying with ASTM D2563, Table I, Level II from the project site.

3.02 SEALING FIELD-CUT FRP:

A. Seal field-cut FRP with a resin that is compatible with the original resin as recommended by the manufacturer.

END OF SECTION

SECTION 09 90 00

PAINTING AND COATING

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section includes materials and application of painting and coating systems.

1.02. DEFINITIONS

A. Definitions:

1. Contractor is the party or persons directly contracted or subcontracted through a third party to perform the work described herein.

2. Engineer is the Engineer of Record for the Project or a representative for the Engineer of Record for the Project.

3. Manufacturer is the materials supplier.

B. Service Condition Identification:

1. A: Atmospheric: Any metal or surface, indoors or outdoors that is exposed to view.

2. ND: Normally Dry: Substrate is exposed to moisture from environmental conditions but remains dry more than 85 percent of its service life.

3. NW: Normally Wet: Substrate is exposed to moisture from environmental conditions and remains moist not less than 85 percent of its service life.

4. S: Submerged: Substrate is continually immersed in an aqueous solution.

5. SP: Splash and Spill: Substrate is frequently subjected to exposure to aqueous solutions, but is generally cleaned up within 2-8 hours

6. UV: Ultraviolet: Substrate is exposed to ultraviolet sunlight.

1.03. REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. A780: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

2. D16: Standard Terminology for Paint, Related Coatings, Materials, and Applications.

3. D2697: Standard Test Method for Volume Nonvolatile Matter in Clear or Pigmented Coatings.

4. D4417: Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel.

5. D4541: Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers.

6. D7091: Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals.

B. NACE International (NACE):

1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.

2. SP0188-06 - Discontinuity (Holiday) Testing of Protective Coatings.

C. The Society for Protective Coatings (SSPC):

1. SSPC-SP 1 - Solvent Cleaning.

2. SSPC-SP 2 - Hand Tool Cleaning.

3. SSPC-SP 3 - Power Tool Cleaning.

4. SSPC-SP 5 / NACE 1 - White Metal Blast Cleaning.

5. SSPC-SP 6 / NACE 3 - Commercial Blast Cleaning.

6. SSPC-SP 7 - Brush off Blast Cleaning.

7. SSPC-SP 10 / NACE 2 - Near White Metal Blast Cleaning.

8. SSPC-SP 11 - Machine Tool Cleaning to Bare Metal.

9. SPSC-SP 12 / NACE 5 - Waterjet Cleaning.

10. SSPC-SP 13 / NACE 6 - Surface Preparation for Concrete.

11. SSPC-SP 14 / NACE 8 - Industrial Blast Cleaning.

12. SSPC-SP 15 - Commercial Grade Power Tool Cleaning.

13. SSPC-SP 16 - Brush off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non Ferrous Metals.

14. SSPC-SP WJ-1 / NACE WJ-1 Clean to Bare Substrate.

15. SSPC-SP WJ-2 / NACE WJ-2 Very Thorough Cleaning.

16. SSPC-SP WJ-3 / NACE WJ-3 Thorough Cleaning.

17. SSPC-SP WJ-4 / NACE WJ-4 Light Cleaning.

18. SSPC-PA1 - Best Practices for Paints and Coatings Application.

19. SSPC-PA2 - Measurement of Dry Coating Thickness with Magnetic Gauges.

20. SSPC-PA71 - Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements.

D. United States Environmental Protection Agency (EPA):

1. Method 24 - Surface Coatings.

1.04. QUALIFICATIONS

A. Coating manufacturer's authorized representative shall provide a written statement attesting that the applicator has been instructed on proper preparation, mixing and application procedures for coatings specified.

B. Applicators shall have a minimum of 5 years of experience in the application of similar products on similar projects.

1. The contractor shall possess a valid state license as required for performance of the painting and coating work called for in this specification.

2. Provide references for a minimum of 3 different projects completed in the last 5 years with similar scope of work.

a. Include name and address of project, size, and scope of work.

C. Applicators shall possess current SSPC-QP-3 certifications or equivalent as required by the Engineer.

1.05. SUBMITTALS

A. Submit all required documentation noted herein in accordance with Section 01 33 00.

B. Product Data: Manufacturer's data sheets on each paint and coating product should include:

1. Colors available for each product (where applicable).

2. Percent solids by volume.

3. Minimum and maximum recommended dry-film thickness per coat for prime, intermediate, and finish coats.

4. Recommended surface preparation.

5. Recommended thinners.

6. Statement verifying that the specified prime coat is recommended by the manufacturer for use with the specified intermediate and finish coats.

7. Application instructions including recommended equipment and temperature limitations.

8. Curing requirements and instructions.

9. Storage and handling requirements and recommendations.

10. VOC compliance.

11. Material safety data sheets (MSDS) for each coating.

C. Contractor Work Plan:

1. In general, the Contractor shall supply the Engineer with a work plan. The work plan should detail but is not limited to the following items.

    a. Proposed methods of containment, collection, and disposal of related debris, rinse water, or trash.

    b. Proposed surface preparation standards and methods to achieve standard for each space or substrate identified on the Drawings or Finish Schedule.

    c. Proposed coating system for each space or substrate identified on the Drawings or Finish Schedule.

    d. Confirmation of compatibility for shop and field applied coatings. (where applicable).

    e. Proposed methods and equipment to be used for paint application.

f. Proposed methods for maintaining proper environmental conditions during surface preparation, application, and curing cycles of the coating materials.

g. Proposed methods and job safety analysis procedures for maintaining a clean, safe and secure jobsite during work activity.

h. Proposed methods to protect coating during curing, shipping, handling, and storage.

i. Proposed methods for storing materials.

j. Proposed methods and examples of daily reports of Contractor work progress.

k. Potential hazards and mitigation, work processes, scheduling conflicts or other planning items which would hinder successful and timely completion of the Project.

D. Selection Samples: Submit a complete set of color chips that represent the full range of manufacturer's color samples available for each type of coating system.

1.06. QUALITY ASSURANCE

A. Quality assurance procedures and practices shall be at the discretion of the Engineer and Maine DMR. It provides oversight of quality control monitoring of all phases of the installation process including but not limited to surface preparation and application of coatings.

1. Requirements for acceptable quality control methods shall be utilized and defined by the Engineer and Maine DMR.

2. Procedures or practices for quality control practices not specifically defined in this Section may be utilized, provided they meet recognized and acceptable professional standards and are accepted by the Engineer and Maine DMR.

3. Arrange for coating manufacturer's representative to attend preconstruction conferences and make periodic visits at the construction site to provide consultation services during surface preparation work and application of coatings.

4. Quality assurance activities may be performed by a third party inspection firm contracted by Maine DMR or specifying Engineer on their behalf at any time during the Project.

B. Pre-Installation Conference:

1. The Contractor, the installation sub-contractor, and the coating system manufacturer's representative shall meet on site with the Engineer. Particular emphasis shall be placed on these specification requirements, safety, weather conditions, surface preparation, material application, and inspection.

2. The Contractor shall submit to the Engineer any revisions or changes agreed upon, reasons thereof, and parties agreeing or disagreeing with them.

C. Surface Preparation: Preparation of all surfaces and application of coatings specified in this section shall be in strict accordance with coating manufacturer's instructions as supplemented by these specifications.

D. Coating Application: Apply coatings in strict accordance with manufacturer's material data sheets with particular attention to curing and drying times and temperatures.

E. Inspection of Dry Film: Thickness of coatings shall be checked with a nondestructive, magnetic-type thickness gauge.

1. Ensure all dry film thickness requirements as specified have been met. Readings shall be performed at or above the frequency specified in SSPC-PA2. Meet the minimum requirements for SSPC-PA2.

2. Use an instrument such as a Tooke Gauge if a destructive tester is deemed necessary.

3. Test coating integrity of all surfaces with an approved inspection device.

4. Holiday detection testing: Shall be accomplished over 100 percent of coated surfaces, and in strict accordance with NACE SP0188.

a. For "high voltage" holiday inspection equipment used to inspect film thickness between 20 -50 mils adjusted voltage shall not exceed voltage recommended by manufacturer of coating system.

b. For "wet sponge" holiday inspection equipment used to inspect film thickness between 8 and 10 mils, add a non-sudsing type wetting agent to water prior to wetting detector sponge.

5. No pinholes or other irregularities will be permitted in final coating.

F. Inspection Testing Devices: Provide the following testing devices to be jointly used on this Project by the Contractor and Engineer. Devices shall remain property of the Contractor during and after the Project.

1. Surface profile Comparator or Testex Tape to measure surface profile prior to coating application.

2. Psychrometer and psychometric tables or charts for humidity and dew point determination.

3. Dry film thickness gauge and calibration blocks for coating thickness testing.

4. Wet film thickness gauge for coating thickness testing.

5. 10 times magnifier for examination.

6. Holiday detector and associated equipment for coating defect determination.

7. Combustible gas analyzer (sniffer) for safety.

G. Documentation: Provide daily reports of all Contractor activity on site to the Engineer on the Friday, end of work week, for the previous week's activity.

1. Document sample shall be approved by the Engineer prior to reporting.

2. All documentation shall be delivered electronically to the Engineer upon completion of the Project.

3. Documentation should be consistent with inspection reports utilized by NACE certified inspectors.

1.07. DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver manufacturer's unopened containers to the work site. Packaging shall bear the manufacturer's name, label, and the following list of information:

1. Product name, type (description).

2. Application and use instructions.

3. Surface preparation.

4. VOC content: for two component products, provide mixed VOC in g/L.

5. Environmental issues.

6. Batch date.

7. Color number.

B. Storage: Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1. Store materials in an area that is within the acceptable temperature range, per manufacturer's instructions. Protect from freezing.

C. Handling: Maintain a clean, dry storage area, to prevent contamination or damage to the coatings.

1.08. PROJECT CONDITIONS

A. Maintain environmental conditions during surface preparation, application, and curing of installed coating system.

1. Temperature, humidity, and ventilation must be within limits recommended by manufacturer for optimum results. Do not apply coatings under environmental conditions outside manufacturer's absolute limits.

B. Dehumidification and heating for coating of immersion environments shall be effectively designed and used when needed to maintain proper environmental conditions for proper surface preparation, coatings application, and curing of the installed coating.

1. Confirm site electrical power source availability prior to bidding the Project. If on site power is not available, provide internal combustion engine generators of sufficient power for the dehumidification and heating equipment.

C. Heating equipment including electric, indirect combustion, indirect fired, or steam coil methods may be used.

1. Direct fired propane heaters shall not be used during surface preparation, application and curing of the coating.

2. Heating equipment shall be intrinsically safe or deemed safe by safety personnel prior to use on the job site.

D. Substrate moisture content shall be below manufacturer's recommendation for each substrate to be coated.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

A. Acceptable Manufacturer: The Sherwin-Williams Company, 101 Prospect Avenue NW, Cleveland, OH 44115, www.sherwin-williams.com. Manufacturer Representative: Brian Oras, 617-947-1005, brian.oras@sherwin.com.

B. Substitutions: The Contractor shall identify any proposed product substitutions a minimum of 60 calendar days prior to use. Product substitutions are only allowed when accepted by the Engineer, Woodland Pulp, and Maine DMR as “or equal”. Submittals shall be in accordance with Specification 01 33 00.

C. To establish equality the Contractor shall furnish satisfactory documentation from the manufacturer of the proposed substitute or "or-equal" product that the material meets the indicated requirements and is equivalent or better in the following properties.

1. Quality.
2. Durability.
3. Resistance to abrasion, impact, or physical damage.
4. Life expectancy.
5. Ability to recoat in the future.
6. Solids content by volume.
7. Dry film thickness per coat.
8. Compatibility with other coatings.
9. Suitability for the intended service.
10. Resistance to chemical attack.
11. Temperature limitations during application and in service
12. Comparable performance test results.

D. Protective coating materials shall be standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. When requested, the Contractor shall provide the Engineer with the names of not less than 10 successful applications of the proposed manufacturer's products that comply with these requirements.

E. Standard approved painting, coating, and lining systems are defined herein. Apply approved systems according to the Finish Schedule.

2.02. PAINTING AND COATING SYSTEMS

A. The following index lists the various painting and coating systems by service and generic type:

Service Type/Location	Service Condition(s)	System No.	Generic Coating
Steel Trough and Flume Interior Lining (Wet Side)	A, NW, S, UV	10A	Elastomeric Polyurethane
		10B	Epoxy
Steel Trough and Flume Exterior Coating (Dry Side)	A, ND, UV	20A	Elastomeric Polyurethane
		20B	Epoxy
Steel Pipe Interior Lining	NW, S	30A	Elastomeric Polyurethane
		30B	Epoxy
Steel Pipe Exterior Coating	A, ND, UV	40	Epoxy Siloxane Hybrid
Other Steel Exterior Coating	A, ND, SP, UV	50	Epoxy Siloxane Hybrid
Repair of Galvanized Surfaces	Repair Damaged Surfaces	100	Cold Galvanizing Compound
Aluminum Protection/Insulation	Insulate from Concrete & Carbon Steel	200	Epoxy

B. Refer to Paragraph 1.02.B for Service Condition definitions.

2.03. STEEL TROUGH AND FLUME: INTERIOR LINING (WET SIDE)

A. Service conditions: A, NW, S, UV.

B. Use System No. 10A - Elastomeric Polyurethane Lining or System No. 10B - Epoxy Lining.

C. System No. 10A - Elastomeric Polyurethane Lining:

1. Surface preparation: SSPC-SP-10, 3 mil profile.

2. Minimum total film thickness, 32 mils dft.

3. Color: Beige or Off White.

4. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

   a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

5. Prime:

   a. Primer (optional), Minimum to Maximum 2 to 2.5 mils dft: Corothane Galvapac 1K, B65 Series.

6. Finish: PolyCote 110, B62 Series, 30 to 40 mil dft.

D. System No. 10B - Epoxy Lining:

1. Surface preparation: SSPC-SP-10, 3 mil profile.

2. Minimum total film thickness, 25 mils dft.

3. Color: Beige or Off White.

4. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

    a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

5. Finish: Sher-Plate PW, B62 Series, 25 to 30 mil dft.

2.04. STEEL TROUGH AND FLUME: EXTERIOR COATING (DRY SIDE)

A. Service conditions: A, ND, UV.

B. Use System No. 20A - Elastomeric Polyurethane Lining <u>or</u> System No. 20B - Epoxy Lining.

C. System No. 20A - Exterior Elastomeric Polyurethane Coating:

1. Surface preparation: SSPC-SP-10, 3 mil profile.

2. Minimum total film thickness, 36 mil dft.

3. Color: Light color selected by Woodland Pulp.

4. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

    a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

5. Prime:

    a. Primer (optional), Minimum to Maximum 2 to 2.5 mils dft: Corothane Galvapac 1K, B65 Series.

6. Intermediate: PolyCote 110, B62 Series, 30 to 40 mil dft.

7. Topcoat: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

D. System No. 20B - Exterior Epoxy Coating:

1. Minimum total film thickness, 31 mil dft.

2. Color: Light color selected by Woodland Pulp.

3. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

    a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

4. Prime:

    a. Primer (optional), Minimum to Maximum 2 to 2.5 mils dft: Corothane Galvapac 1K, B65 Series.

5. Intermediate: Sher-Plate PW, B62 Series, 25 to 30 mil dft.

6. Topcoat: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

2.05. STEEL PIPE: INTERIOR LINING

A. Service conditions: NW, S.

B. Use System No. 30A - Elastomeric Polyurethane Lining <u>or</u> System No. 30B - Epoxy Lining.

C. System No. 30A - Elastomeric Polyurethane Lining:

1. Surface preparation: SSPC-SP-10, 3 mil profile.

2. Minimum total film thickness, 32 mils dft.

3. Color: Beige or Off White.

4. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

    a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

5. Prime:

    a. Primer (optional), Minimum to Maximum 2 to 2.5 mils dft: Corothane Galvapac 1K, B65 Series.

6. Finish: PolyCote 110, B62 Series, 30 to 40 mil dft

D. System No. 30B - Epoxy Lining:

1. Surface preparation: SSPC-SP-10, 3 mil profile.

2. Minimum total film thickness, 25 mils dft.

3. Color: Beige or Off White.

4. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

   a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

5. Finish: Sher-Plate PW, B62 Series, 25 to 30 mil dft.

2.06. STEEL PIPE: EXTERIOR COATING

A. Service conditions: A, ND, UV.

B. System No. 40 - Epoxy Siloxane Hybrid Coating:

1. Surface preparation: SSPC-SP-6, 2 mil profile.

2. Minimum total film thickness, 11 mil dft.

3. Maximum total film thickness, 16 mil dft.

4. Color: Light color selected by Woodland Pulp.

5. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

   a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

6. Primer: Min. to Max. 3 to 4 mils dft: Corothane Galvapac 1K, B65 Series.

7. Intermediate: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

8. Topcoat: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

2.07. OTHER STEEL: EXTERIOR COATING

A. Service conditions: A, ND, SP, UV.

B. System No. 50 - Epoxy Siloxane Hybrid Coating:

1. Surface preparation: SSPC-SP-6, 2 mil profile.

2. Minimum total film thickness, 11 mil dft.

3. Maximum total film thickness, 16 mil dft.

4. Color: Selected by Woodland Pulp.

5. Utilize epoxy fairing compound to fill pits, voids, or smooth surface irregularities.

a. Filler and Surfacing Epoxy: Steel Seam FT910, as needed to fill voids or surface irregularities.

6. Primer: Min. to Max. 3 to 4 mils dft: Corothane Galvapac 1K, B65 Series.

7. Intermediate: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

8. Topcoat: Sher-Loxane 800, B80 Series, 4 to 6 mil dft.

2.08. REPAIR OF GALVANIZED STEEL SURFACES

A. Service Conditions: Repair of damaged galvanized coatings on steel surfaces.

B. System No. 100 – Cold Galvanizing Compound:

1. Type: Cold galvanizing compound consisting of paint containing oils, solvents, and zinc dust and complying with MIL-P-21035. Minimum metallic zinc content in the cured coating shall be 90%.

2. Surface preparation: Clean damaged surfaces per SSPC-SP-1 and SSPC-SP-11.

3. Coating System: Apply Z.R.C. Galvanizing Compound, RAMCO Specialty Products "Zinckit," NuWave "Galv-Match-Plus," Devcon "Cold Galvanizing," Clearco "Cold Galvanizing Spray," or equal.

4. Minimum dry-film thickness of 3 mils.

5. Apply per ASTM A780, Annex A2.

2.09. ALUMINUM PROTECTION

A. Service Conditions: Aluminum insulation from concrete and carbon steel.

B. System No. 200 – Aluminum Protection:

1. Type: High solids epoxy or phenolic epoxy having minimum volume solids of 80% (ASTM D2697).

2. Surface preparation: Solvent or steam cleaning per SSPC-SP-1; do not use alkali cleaning. Then dust blast.

3. Coating System: Apply 3 or more coats of Ameron 400, Tnemec Series 135, ICI Devoe Bar-Rust 233H, Sherwin-Williams Macropoxy B58-600, PPG PITT-Guard Direct-to-Rust Epoxy Mastic Coating 97-145 series, or equal.

4. Minimum total film thickness, 30 mil dft. Maximum thickness of an individual coating shall not exceed the manufacturer’s recommendation.

PART 3 - EXECUTION

3.01. EXAMINATION

A. Examine all substrates and conditions, with Contractor and Engineering representative present for compliance with requirements for maximum moisture content, surface soundness, and other conditions affecting the performance of the Work.

B. Do not begin application of coatings until substrates have been properly prepared, examined, and conditions properly reported. Notify Engineer of unsatisfactory conditions or areas where specified surface preparation cannot be achieved.

C. If substrate preparation is the responsibility of another installer, notify Engineer of unsatisfactory preparation. Proceed with work only after conditions have been corrected, and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions. Beginning coating application constitutes Contractor's acceptance of substrate and conditions.

D. Identify all shop primed items and previously painted surfaces and provide preparation procedures for review and approval.

3.02. SURFACE PREPARATION:

A. General:

1. The surface must be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.

2. Follow all surface preparation guidelines for new construction. In the event of a discrepancy consider the more effective surface preparation as the default method.

3. Verify that the atmospheric conditions are within the acceptable temperature, humidity and sun exposure limits.

a. Dehumidification must be utilized in the event that atmospheric conditions cannot be maintained.

4. Adhere to manufacturer's recoat time surface preparation requirements.

a. Surfaces exhibiting rust bloom, moisture weeping, or any other deleterious condition shall be sufficiently repaired prior to the application of coating or lining system. Repair methods include necessary means to meet original specification requirements, including abrasive blasting as needed.

5. Remove any residual dusting or light surface contamination from prepared surfaces prior to the application of the coating system.

6. Protect all surfaces not being coated from any damage due to surface preparation work.

7. Paint all inaccessible items before being assembled.

8. Install coating systems to only properly prepared surfaces.

B. Abrasive Blast Cleaning:

1. Blast cleaned surfaces shall match the standard samples available from the NACE Standard TM-01-70, Visual Standard for Surfaces of New Steel Air Blast Cleaned with Sand Abrasive and TM-01-75, Visual Standard for Surfaces of New Steel Centrifugally Blast Cleaned with Steel Grit.

2. Remove all oil, grease, welding fluxes, and other surface contaminants by solvent cleaning per SSPC-SP1prior to any mechanical surface preparation.

3. Sharp edges shall be rounded or chamfered; burrs, surface defects, and weld splatter shall be ground smooth prior to blast cleaning in accordance with NACE SP0178-07, Design, Fabrication, and surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.

4. The type and size of abrasive shall be selected to produce a surface profile that meets the coating manufacturer's recommendation of the particular product and service conditions. Abrasives for submerged and severe service coating systems shall be clean, hard, sharp cutting crushed slag. Metal shot or grit shall not be used for surfaces in submerged services.

5. Abrasive shall not be reused unless an automated lasting system is used for surfaces that will be in non-submerged service. For automated blasting systems, clean, oil free abrasives shall be maintained. The abrasive mix shall include at least 50 percent grit.

6. Compressed air for blast cleaning shall be supplied at adequate pressure from well-maintained compressors equipped with oil and moisture separators that remove at least 98 percent of the contaminates.

C. Shop Primed Surfaces Surface Preparation for Field Applied Finishes

1. All shop primed surfaces shall be prepared according to the following requirements.

a. Clean all previously coated surfaces to remove dirt, greases, solutions, and any foreign contaminants per SSPC-SP1. Cleaning agent shall be biodegradable, highly concentrated, water reducible, alkaline detergent blend. Cleaned surfaces shall be properly rinsed to remove all cleaners and contaminants.

b. Shop applied primers shall be abraded as needed following cleaning per SSPC-SP1. Overcoating of shop applied epoxy primers shall be within the shop applied manufacturers published recoat parameters. Provide written confirmation of compatibility, timing, and procedure for overcoating from manufacturer.

c. Exposed or corroded substrates shall be mechanically cleaned to remove all corrosion or deteriorated material. Surface preparation requirements of corresponding deteriorated exposed substrate shall be achieved according to original substrate surface preparation for high performance coatings.

d. Sand and feather edge a smooth transition from existing coatings and exposed substrate such that damaged areas are not visible from a distance of two (2) feet.

e. Final surface preparation for existing coatings and deteriorated substrates shall provide intact, tightly adherent coatings, cleaned substrate, dull, and dry.

f. Prime coat used in overcoating existing material must be suitable for the intended use and provide adequate adhesion to the existing material.

g. Overcoating existing coating systems for immersion or submerged conditions shall be made in strict accordance with the coating manufacturer's printed instructions. Coating manufacturer will provide in writing specific steps required to achieve proper adhesion and performance of overcoat system.

3.03. INSTALLATION

A. General Requirements:

1. Apply all coatings and materials according to the Finish Schedule.

2. Apply all coatings and materials with manufacture specifications in mind. Apply coatings by brush, roller, or spray equipment unless otherwise directed by the manufacturer.

3. Mix and thin coatings according to manufacture recommendation.

4. Do not apply to wet or damp surfaces.

5. Uniformly apply coatings without runs, drips, or sags, without brush marks, and with consistent sheen in accordance with SSPC-PA1. Regardless of number of coats specified, apply as many coats as necessary for complete hide, uniform appearance, and achieving the required dry film thickness. Final film of coatings shall have no visible drips, overspray, dry spray, runs, ridges, sags, holidays, dry lap, or brush marks.

6. Inspection: The coated surface must be inspected and approved by the Engineer.

7. Plural component spray applied equipment shall be properly inspected and in working condition prior to the application of materials.

    a. All gauges, valves, pistons, and working parts shall be in proper working order.

    b. Coating materials stored in drums shall be premixed and heated prior to the application of the coating.

    c. Perform successful ratio check of spray material prior to application of coating.

    d. All equipment settings and requirements for proper application including but not limited to pressures, volumes, mix ratio settings, shall be in proper working order and closely monitored during application.

    e. Sample spray application of specific material shall be applied to "sample cards" just prior to the application of plural applied material. Supply sample cards from previous day's application with proper date and time markings to Engineer for verification of cured material.

8. Stripe coats shall be applied to all welds, edges, nuts, bolts, difficult to reach areas.

    a. Stripe coats shall be applied directly to properly prepared surface prior to spray application of primers.

    b. Stripe coats shall also be applied directly to the primed surface prior to spray application of the intermediate coats for multi-coat immersion or submerged applications.

    c. Stripe coat material shall be the same or separately approved material compatible with the material used for spray application of any given coat.

9. Spray application shall be performed when conditions, environments, and permitting allow.

a. Use only spray equipment approved by the manufacturer for the specific coat of material.

10. Multiple coat applications shall be installed according to the manufacturer’s printed requirements.

    a. Coats of material shall be sufficiently dry prior to the application of a subsequent coat in a coating system.

    b. Do not allow excessive drying time to pass which will inhibit or reduce the inter-coat adhesion of the multiple coat system.

    c. If recoat requirements have been exceeded, brush blast or scarify prior coat according to the manufacturer’s requirement. Provide written confirmation of repair process from manufacturer.

    d. Remove any dust or foreign contamination from the previous coat prior to applying the next coat in a multi coat system.

11. Apply no coating when surrounding air temperature of surface to be coated is below minimum temperature allowed by manufacturer's recommendations for coating application or when it is expected that air temperature will drop below minimum 8 hours after coating application.

12. Apply no coating when surrounding air temperature is forecasted to be less than 5 degrees F above dew point within 8 hours after coating application.

13. Apply no coating to steel which is 5 degrees F below air temperature or which is at a temperature over 115 degrees F, nor shall coating be applied to steel which is at a temperature that will cause blistering or porosity or otherwise will be detrimental to the life of the coating.

14. No coating shall be applied to wet or damp surfaces or in rain, snow, fog, or mist. Coating shall not be applied on frosted or ice-coated surfaces.

15. Dew point shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychometric Tables or equivalent.

16. The coated surface must be inspected after application of individual coats within the multi coat system and after completion of the system. Applied systems must be approved by the Engineer.

B. Curing Requirements:

1. Maintain adequate environmental conditions and ventilation during drying and curing of applied coating systems.

2. Allow all primer and intermediate coats to sufficiently dry prior to the application of subsequent coat of material.

3. Coating systems to be placed into immersion service shall cure under the proper conditions as stated by the manufacturer for the full curing time requirement. Deviations from the proper conditions shall be quickly resolved by the Contractor and the methods used shall be confirmed by the manufacturer.

4. All applied coatings shall be properly and completely cured prior to being placed into their intended service.

C. Shop Application:

1. All structural steel members, steel plate, or other manufactured items may be prepared and coated in a fixed location.

2. Shop application of prime coat shall be completed only when specified surface preparation has been achieve for the substrate. Apply all primers within 4 hours of completion of surface preparation. Ferrous metal shall not be primed if rust bloom is present.

3. Field repair any damaged shop primer, intermediate or finish coats in accordance with the preparation requirements for the given substrate. Apply repair primer, intermediate, and finish coats as required to replace damage materials and restore damaged areas equal to surface before damage.

4. Equipment:

   a. Unless otherwise indicated, items of equipment or parts of equipment which are not submerged in service shall be shop primed and finish coated in the field after installation with the indicated or selected color. The methods, materials, application equipment, and other details of shop painting shall comply with this section. If the shop primer requires top coating within a specific period of time, the equipment shall be finish coated in the shop and then touched up after installation.

   b. Items of equipment or parts and surfaces of equipment which are submerged or inside an enclosed hydraulic structure when in service, with the exception of pumps and valves, shall have surface preparation and coating performed in the field.

   c. For certain pieces of equipment, it may be undesirable or impractical to apply finish coatings in the field. Such equipment may include engine generator sets, equipment such as electrical control panels, switchgear or main control boards, submerged parts of pumps, ferrous metal passages in valves, or other items where it is not possible to obtain the indicated quality in the field. Such equipment shall be primed and finish-coated in the shop and touched up in the field with the identical material after installation. The Contractor shall require the manufacturer of each such piece of equipment to certify as part of its Shop Drawings that the surface preparation is in accordance with these specifications. The coating material data sheet shall be submitted with the Shop Drawings for the equipment.

d. For certain small pieces of equipment, the manufacturer may have a standard coating system that is suitable for the intended service conditions. In such cases, the final determination of suitability will be made during review of the Shop Drawing submittals. Equipment of this type generally includes only indoor equipment such as instruments, small compressors, and chemical metering pumps.

e. Shop painted surfaces shall be protected during shipment and handling by suitable provisions including padding, blocking, and the use of canvas or nylon slings. Primed surfaces shall not be exposed to the weather for more than 2 months before being top coated or less time if recommended by the coating manufacturer.

D. Prime Coat Application:

1. Prime all surfaces to be painted, unless noted otherwise.

2. Prime and finish all surfaces that will be inaccessible after installation.

3. Primed substrate shall be of consistent film thickness and coverage to meet the specification.

4. Provide proper environmental conditions for curing of prime coat.

E. Finish Coat Application:

1. Apply all intermediate and finish coats to properly primed substrates within the recoat requirements and according to the product data sheet of the manufacturer.

2. Apply contrasting colors for distinguishing between intermediate and finish coats.

3. Field applied intermediate and finish coats shall be applied to shop primed substrates only within sufficient adhesion can be obtained. When required, thoroughly and completely abrade existing primers and apply a subsequent tie coat of approved primer will be applied to the abraded shop primer.

3.04. QUALITY CONTROL

A. In general, the Contractor will maintain appropriate and measurable quality control activities that ensure successful installation of the coating systems.

B. Measure all dry film thickness readings as defined in SSPC-PA2.

C. Apply all coatings using methods defined in SSPC-PA1.

D. Perform all stripe coating using methods defined in SSPC-PA 11.

E. Maintain and provide to the Engineer copies of daily records of Contractor activity while performing work on the Project. Daily record information should include but is not limited to the following.

1. Site foreman responsible for day's activities.

2. Work hours. Start and finish times.

3. Crew members.

4. Atmospheric measurements during exterior work should include evenly sequenced measurements of general weather condition, wind speed, air temperature, and relative humidity.

5. Atmospheric measurements during high performance coating applications particularly submerged or immersion items should include evenly sequenced measurements of general weather condition, wind speed, air temperature, and relative humidity during all surface preparation, application, and curing of applied systems.

6. Substrate temperatures at the time of application and completion of the application.

7. Measure wet film of applied coating using wet film thickness gauges.

8. Detailed record of start and finish times of activities performed on a given space.

F. Maintain accurate quality control records of applied coating systems.

1. Record accurate dry film thickness readings in accordance with SSPC-PA 2.

G. Supply daily reports on a timely basis to the supervising Engineer.

3.05. PROTECTION

A. Protect finished coatings from damage until completion of Project.

1. Applied coatings shall not be placed into service until properly cured.

2. Maintain acceptable environmental conditions for proper curing of the applied coating system.

B. Touch-up damaged coatings after substantial completion, following manufacturer's recommendation for touch up or repair of damaged coatings. Repair any defects that will hinder the performance of the coatings.

3.06. FINISH SCHEDULE

A. General:

1. All items not specifically listed in the Finish Schedule shall receive a coating system consistent with corrosive atmosphere or submerged coating schedule by the corresponding substrate and service environment as shown on the Drawings.

2. Any discrepancy in the Drawings or Finish Schedule will default to the high performance coating system as shown per substrate, intended service environment and the corresponding surface preparation requirements.

3. All substrates shall require finish painting unless specifically noted otherwise.

FINISH SCHEDULE				
ID	Item	Material	Coating	Ref. Dwg
~~1~~	~~Transition Flume (Not in Contract)~~	~~Carbon Steel~~	~~System 10 (Interior)~~ ~~System 20 (Exterior)~~	~~C-161~~
~~2~~	~~Eel Bypass, Piping, & Valves (Not in Contract)~~	~~Stainless Steel~~	~~N/A~~	~~C-162~~
~~3~~	~~Trash Rack Steel Framing (Not in Contract)~~	~~Carbon Steel~~	~~Galvanized~~	~~C-161~~
4	Access Bridge	Carbon Steel	Per Manufacturer	C-180
5	Vehicle Guard Rail	Carbon Steel	Galvanized	C-186
6	AWS Pipe 1,Valves, & Actuators	Carbon Steel	System 30 (Interior) System 40 (Exterior)	C-301
7	AWS Pipe 2,Valves, & Actuators	Carbon Steel	System 30 (Interior) System 40 (Exterior)	C-302
8	AWS Pipe 3,Valves, & Actuators	Carbon Steel	System 30 (Interior) System 40 (Exterior)	C-303
9	Fish Bypass 1, Valves, & Actuators	Carbon Steel	System 30 (Interior) System 40 (Exterior)	C-304
10	Fish Bypass 2, Valves, & Actuators	Carbon Steel	System 30 (Interior) System 40 (Exterior)	C-306
~~11~~	~~Fish Bypass 3, Valves, & Actuators (Not in Contract)~~	~~Carbon Steel~~	~~System 30 (Interior)~~ ~~System 40 (Exterior)~~	~~C-307~~
12	Staff Gauges	PVC	N/A	M-001
13	Permanent Stop Logs & Spacer Frames	Aluminum	N/A	M-001
14	Hoists & Cranes	Carbon Steel	Per Manufacturer	M-001
15	Gates	Carbon Steel	See Spec. 35 20 16	M-001
16	Vgate Grating Panels	Stainless Steel	N/A	M-102
17	Vgate Operator Supports	Carbon Steel	Galvanized	M-103
18	Vgate Operating Stem	Stainless Steel	N/A	M-103
19	Vgate Grating Guides	Carbon Steel	Galvanized	M-105
20	Vgate Bearing Assemblies	Stainless Steel	N/A	M-106
21	Fish Lift Hopper	Carbon Steel	Galvanized	M-110
22	Fish Lift Hopper Gate	Stainless Steel	N/A	M-112
23	Fish Lift Hopper Gate Guide Frame	Carbon Steel	Galvanized	M-113
24	Fish Lift Hopper Lifting Frame	Carbon Steel	Galvanized	M-114
25	Fish Lift Hopper ASCE Rail	Carbon Steel	Galvanized	M-115
26	Perforated Plate Framing	Carbon Steel	Galvanized	M-119
27	Perforated Plate	Carbon Steel	Galvanized	M-119
28	Wedge Wire Screen	Stainless Steel	N/A	M-121
29	Wedge Wire Screen Support Members	Carbon Steel	Galvanized	M-121
30	Exit Flume Baffle	Carbon Steel	Galvanized	M-121
31	Fish Holding Tank Small Diameter Piping	Stainless Steel	N/A	M-123
32	Removable Crowder Screen	Carbon Steel	Galvanized	M-129

33	Trap Gate Operator Support	Carbon Steel	Galvanized	M-125
34	Trap Gate Operating Stem	Stainless Steel	N/A	M-125
35	Trap Gate Grating Panels	Stainless Steel	N/A	M-125
36	Trap Gate Bearing Assembly	Stainless Steel	N/A	M-126
37	Moving Floor	Stainless Steel	N/A	M-128
38	Exit Flume Wedge Wire Screen	Stainless Steel	N/A	M-130
39	Exit Flume Wedge Wire Screen Support Framing	Carbon Steel	Galvanized	M-130
40	Exit Flume Isolation Gate Guide Frame	Carbon Steel	Galvanized	M-131
41	Automated Gate Weir	Carbon Steel	See Spec. 35 20 16	M-142
42	Downstream Isolation Gate Guide Frame	Carbon Steel	See Spec. 35 20 16	M-142
43	Stilling Wells	Stainless Steel	N/A	M-200
44	Fasteners (Bolts, Studs)	Carbon Steel	Galvanized, UNO	S-001
45	Viewing Room Framing	Carbon Steel	Galvanized	S-128
46	Viewing Room Interior	Plywood	Paint	S-128
47	Viewing Room Exterior	Sheet Metal	N/A	S-128
48	Bar Rack	Carbon Steel	Galvanized	S-130
49	Exit Flume Framing	Carbon Steel	System 20 (Exterior)	S-131
50	Exit Flume Skin Plates	Carbon Steel	System 10 (Interior) System 20 (Exterior)	S-131
51	Exit Flume Support Framing	Carbon Steel	System 20 (Exterior)	S-133
52	Exit Flume Transition Pieces	Carbon Steel	System 10 (Interior) System 20 (Exterior)	S-135
53	Exit Flume at Fish Lift	Carbon Steel	System 10 (Interior) System 20 (Exterior)	S-136
54	Steel Trough & Transition Flume	Carbon Steel	System 10 (Interior) System 20 (Exterior)	S-160
55	Downstream Fish Passage Flume	Carbon Steel	System 10 (Interior) System 20 (Exterior)	S-174
56	Tapered Beams	Carbon Steel	Galvanized	S-175
57	Electrical Enclosure	Carbon Steel	Per Manufacturer	S-190
58	Fish Lift Tower Framing	Carbon Steel	Galvanized	S-200’s
59	Pipe Support Framing	Carbon Steel	Galvanized	S-300’s
60	Pipe Support Cradles	Carbon Steel	Galvanized	S-300’s
61	Stairs & Platforms	Carbon Steel	Galvanized	S-413
62	Micropile Casing & Top Plate	Carbon Steel	Galvanized	S-459
63	Ladders & Ship Ladders	Carbon Steel	Galvanized	S-503
64	Fencing	Carbon Steel	Galvanized	S-505
65	Railing	Carbon Steel	Galvanized	S-504
66	Concrete	Concrete	N/A	
67	Concrete Embedments	Carbon Steel, UNO	Galvanized, UNO	

END OF SECTION

SECTION 11 10 00

MOTORS

PART 1 - GENERAL

1.01. SUMMARY

A. Provide electric motor, actuator, and gearbox per Contract Drawings.

1.02. SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Product Data: Submit manufacturer's technical product data on motors.

C. Maintenance Data: Submit maintenance data and parts list for each motor. Include this data and product data in the maintenance manual.

D. Submit details and calculations for actuator support for items not detailed on the Drawings.

1.03. CODES AND STANDARDS

A. NEC Compliance: Comply with NEC as applicable to installation and construction of motors.

B. NEMA Compliance: Comply with applicable requirements of NEMA Std Pub No.'s MG-1 and MG-13.

1.04. QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of motors of the types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with motor work similar to that required for the project.

PART 2 - PRODUCTS

2.01. ELECTRIC ACTUATOR

A. Rotork Electric Actuator (Multi-Turn) Model IQ or approved equal

B. Rotork Electric Actuator (Quarter-Turn) model IQ T or approved equal

C. Actuator support supplied by gate manufacturer, unless otherwise shown on the Drawings.

2.02. GEARBOX

A. Rotork interconnected Model IB gearboxes or approved equal

2.03. ELECTRIFICATION

A. Power supply for the lifting mechanisms shall be 480 Volts, 3 Phase, 60 Hertz. All power required for the operation of the lifts shall be developed from a single such branch circuit.

B. For each lifting unit, the Supplier shall provide a non-fused, 480 Volt, 3 phase manual disconnect switch designed and installed in accordance with the requirements of the National Electric Code. Opening of main line manual disconnect shall completely de-energize the lifting unit. The main disconnect switch shall be capable of being padlocked in the “Off” position.

C. Protect and enclose electrical terminations and connections.

D. All enclosures shall be NEMA 4 or better.

E. Ground electric motors and structural frames.

PART 3 - EXECUTION

3.01. CONSTRUCTION AND SELECTION

A. Where starting restrictions are necessary, permissible successive starts, without loss of life, shall be clearly stated on the nameplate.

B. Terminal boxes shall be located and sized in accordance with NEMA Standards. Motor leads shall be identified in accordance with NEMA MG1-2.61.

C. Motors shall operate without excessive noise under no load conditions as required by NEMA MG1-12.49.

D. Motor vibration shall not exceed values given in NEMA MG1-12.05.

E. The minimum amount of information provided on the nameplates of all motors shall be in accordance with NEMA MG1-10.37 and 10.38, and 10.65.

F. If a motor is designed for only one direction of mechanical rotation, an arrow on the enclosure shall so indicate that direction.

G. Motors shall have roller-contact bearings with suitable seals to prevent leakage of lubricant in either direction along the shaft. Grease lubricated bearings shall be lubricated prior to shipment.

H. Bearings requiring periodic regreasing shall have provisions for in-service positive lubrication with means to prevent damage due to over greasing. Sealed bearings are not acceptable. The LIO service life of roller bearings shall not be less than 100,000 hours at the design speed and horsepower. These service hours shall represent the life that ninety (90) percent of the bearings will complete or exceed in accordance with ANSI B3.15 and B3.16.

I. Vertical motors shall have roller-contact guide and thrust bearings. The thrust bearings shall be capable of supporting the motor and pump rotating parts and the hydraulic thrust due to the load.

J. The motor half of the coupling shall be mounted on the shaft if the motor is shipped separately.

K. All totally enclosed motors shall have at least one drain hole with pipe plug at each end. Screens shall be provided on all intake and discharge air ventilation openings for drip-proof motors.

L. Contractor shall be responsible to assure proper selection of motor for the driven equipment. Contractor is responsible for successful operation of the motor-driven equipment assembly.

M. Motors powered by variable frequency drives shall be manufactured as inverter duty rated.

3.02. STORAGE AND HANDLING

A. The Contractor shall receive, inspect, store, maintain and protect all motors which are shipped separately, whether purchased with the driven equipment or from the motor manufacturer. The Contractor shall be responsible for the care of motors factory-installed on, and connected to, the driven equipment, or furnished unmounted but shipped with it by the driven equipment manufacturer.

B. Receiving inspection of motors shall include checking to ensure that oil was drained from bearings of oil lubricated motors before shipment, and that protective coatings on bare machined metal surfaces such as shafts and coupling remain intact. Certain large motors are shipped to the driven equipment manufacturer for driving the equipment during tests and reshipped to the plant site on completion of testing. Particular care shall be used in the inspection of these items to ensure that they were properly prepared and protected for reshipment, and that they are undamaged and in "as new" condition. The Contractor shall report promptly to the Engineer any bearings which appear to have incompletely drained, evidence of oil leakage into windings, rust, damage, or lack of protective coating on machined surfaces, and excessive dirt or other evidence of insufficient protection before and during reshipment.

C. When practicable, motors shall be stored at their permanent locations. Wherever stored, protection, maintenance, and periodic inspection procedures meeting the requirements of the motor manufacturer's instructions shall be used. As a minimum requirement, motor shutdown heaters (where furnished) shall be connected to a temporary power supply and energized. Power supplies for motor shutdown heaters are to be derived through hard wiring. Plugging heaters into crafts service extension cables is not acceptable. Motors without space heaters shall be stored in a dry indoor location with temperature maintained above the dew point.

D. When handling or moving oil lubricated motors, all oil shall be drained from bearing reservoirs. To prevent seepage of residual oil into windings through ineffective stationary shaft seals, horizontal shaft motors shall be moved with shafts horizontal. In no case shall they be positioned or moved with shafts vertical. Vertical shaft motors shall be handled and moved with shafts vertical.

E. Motor heaters shall be served from power sources of correct voltage. When connected for temporary protection during storage, a 15 watt red lamp shall be used in parallel with the heaters and located conspicuously adjacent to each stored motor, to monitor the heater circuit.

3.03. INSTALLATION

A. Install actuator supports per the manufacturer's recommendations.

B. Installation must meet Woodland Pulp’s requirements for precision alignment and installation shall be documented.

C. The Contractor shall move each large motor from storage and shall rough-set it on its foundation. Before placing a large, heavy motor on a concrete foundation, a check shall be made to assure that concrete has been properly cured. Motor leveling, alignment, grouting, doweling, and coupling to driven equipment shall be done in accordance with the project specifications and drawings.

D. After a motor is set, aligned, and mechanically uncoupled, raceway and cable extensions to motor terminal boxes shall be completed and motor frame grounds connected. Incoming cables and motor winding pigtails shall be terminated. Final connections shall be made to motor terminals for heaters, resistance temperature detectors, bearing thermocouples, and current transformers, if furnished.

E. On completion of testing, motor main connections shall be made up and all terminal box closures installed. If necessary, the Contractor shall modify or replace any motor termination box in order to accommodate cable entry. Any box used to replace the manufacturer's motor box shall be designed to accommodate cable entry. Any box used to replace the manufacturer's motor box shall be designed to accept at least the minimum bending radius of the cable and withstand all environmental conditions.

F. After the motor has been set, aligned and connected, bearings shall be checked and lubricated with the motor mechanically uncoupled. The type and quantity of oil or other lubricant used shall be in strict accordance with the manufacturer's instructions.

END OF SECTION

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SECTION 26 27 16

ELECTRICAL EQUIPMENT ENCLOSURE

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section includes materials, installation, and manufacturer's design of a prefabricated walk-in electrical equipment enclosure, including structural framing, floor, wall and roof panels, and insulation. Electrical equipment enclosure shall be complete with electrical equipment as specified herein and as shown in the Drawings including, but not limited to, HVAC equipment, electrical lighting, conduit and wiring.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. Snow, Wind, and Seismic Design Criteria: 01 81 10.

1.03. SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit letter of certification identifying the electrical equipment enclosure manufacturer as an AISC Class MB certified fabricator and that all building components will be designed in accordance with the 15th edition of the AISC Specifications for the Design, Fabrication, and Erection of Structural Steel.

C. Submit certification that the electrical equipment enclosure manufacturer has been in business for at least 10 years and has designed and supplied at least five electrical equipment enclosures similar to the specified project enclosure. Include names of owners and locations for the referenced enclosures.

D. Submit manufacturer's catalog data describing the enclosure construction and components. Submit project-specific design and installation drawings; shop painting and finishing specifications; instruction manuals; and other data to describe the design, materials, sizes, layouts, construction details, fasteners, and installation.

E. Submit engineering design calculations for structural members and covering components, equipment supports, and base anchorage. Submit the stress values utilized in the analysis stating the design criteria and procedures used. Design calculations shall be signed by a civil or structural professional engineer.

F. Submit certificate that the design meets the applicable building codes.

G. Submit installation drawings and diagrams for the enclosure. Submit calculations verifying the base anchorage indicated in the drawings are adequate to accommodate the project-specific enclosure reactions. Show base anchorage details.

H. Submit drawings showing lifting points and weights.

I. Submit color charts of the colors available for wall and roof panels. Submit panel configuration.

J. Show keying system for door locks, which shall match Woodland Pulp's other facilities.

1.04. LABELING OF ELECTRICAL AND HVAC EQUIPMENT

A. Electrical and HVAC equipment shall be listed and labeled in accordance with Woodland Pulp standard.

1.05. GUARANTEE

A. The electrical equipment enclosure shall be guaranteed against water leaks arising out of or caused by ordinary wear and tear by the elements for a period of five years. Such guarantee is in addition to the guarantee required in the General Conditions and shall start upon final acceptance of the work by Woodland Pulp and Maine DMR.

B. Electrical and HVAC components of the enclosure shall be guaranteed against defects in materials and workmanship for a period of one year.

PART 2 - MATERIALS

2.01. MANUFACTURERS

A. Electrical equipment enclosure (building) shall be manufactured by Square D (power zone center), Powell Electrical Manufacturing Company, Cutler-Hammer (Electro/Center, General Electric (Power Equipment Centers), Easter Owens, Metron, or approved equal.

2.02. DESIGN CRITERIA

A. Electrical equipment enclosure shall be of the size and configuration shown on the Drawings, complete with all accessories.

B. The design of the enclosure and components shall be in accordance with Metal Building Manufacturer's Association's "Recommended Design Practices Manual," latest edition, and the International Building Code (IBC). Design enclosure for the dead load, specified live load, and the combinations of these loads as set forth in the IBC. Include the following loads in addition to the dead load:

1. Refer to Section 01 81 10 for snow, wind, and seismic design criteria.

2. The enclosure shall be designed for a minimum uniform floor loading load of 250 psf in addition to the dead load of the enclosure, unless the weights and floor loading requirements of the installed electrical equipment are greater, in which case the greater values shall be used.

C. Design structural steel members in accordance with AISC publication, "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings." Design structural cold formed steel framing members in accordance with AISI publication, "Specification for the Design of Cold-Formed Steel Structural Members."

D. Design framed openings to replace structurally the covering and framing displaced.

E. Welding of steel shall be in accordance with AWS D1.1.

F. Except as modified hereinafter, design steel covering in accordance with AISI publication "Specification for the Design of Cold-Formed Steel Structural Members. Maximum wind load deflection for wall sheets shall not exceed 1/180th of the span between supports, and maximum live load deflection for roof sheets shall not exceed 1/180th of the span between supports. Maximum deflections shall be based on sheets continuous across two or more supports with sheets unfastened and fully free to deflect.

2.03. ASSEMBLY AND DISASSEMBLY

A. The prefabricated components and the field connections at shipping splits required for site assembly shall utilize the enclosure manufacturer's standard fasteners and construction tools. The maximum size of any shop-assembled component of the enclosure shall permit transportation from factory to site by commercial carrier.

B. Seal open areas at shipping splits with shipping covers to protect the enclosure interior from the elements.

C. Clearly and legibly mark each and every piece and part of the assembly to correspond with previously prepared installation drawings, diagrams, and/or instruction manuals.

2.04. EXTERIOR COVERING

A. Covering shall be minimum 24-gauge galvanized steel conforming to ASTM A653, G90 coating designation, factory color finished.

2.05. ACCESSORIES

A. Flashing, trim, metal closure strips, caps, and similar metal accessories shall be not less than the minimum thicknesses specified for covering. Molded closure strips shall be bituminous-saturated fiber, closed-cell or solid-cell synthetic rubber or neoprene, or polyvinyl chloride premolded to match configuration of the covering.

2.06. FASTENERS

A. Fasteners for securing covering and accessory items shall be Type 316 stainless steel.

B. Provide gasketed washers of a material compatible with the covering and with a minimum diameter of 3/8 inch for structural connections to waterproof the fastener penetration on the exterior side. Gasketed portion of washers shall be neoprene or other equally durable elastomeric material approximately 1/8 inch thick. Exposed wall fasteners shall be factory color finished or provided with plastic color caps to match the covering.

2.07. PANEL INSULATION

A. Provide factory insulated wall panels which provide a minimum R-value of 20, and factory or field assembled insulated roof panels which provide a minimum R-value of 49. Interior and exterior faces of both wall and roof panels shall be made of the same material as the building covering. The core of the panels shall be polyurethane foam with a minimum of 95% closed cell structure.

2.08. DOORS, FRAMES, AND HARDWARE

A. Provide the building with 18-gauge galvanized steel doors of double wall construction and insulated to the same R-value as the walls. Personnel doors shall be 3 feet wide by 7 feet high. Equipment double doors shall be a pair of 3 feet wide by 8 feet high doors, or sized to meet the requirements of the installed electrical equipment, whichever is larger. Provide each door with a 14-gauge gasketed doorframe with ¾-inch stepped steel threshold and three 4-1/2-inch hinges with vandal-resistant, nonremovable hinge pins. Above each door, provide a rain drip cap. Lockset shall be Schlage extra heavy duty. Door swings shall be as shown on the Drawings.

2.09. WARNING SIGNS

A. Warning sign conforming to ANSI Z535 and reading DANGER HIGH VOLTAGE – KEEP OUT shall be provided on the doors. Sign shall be enameled steel and shall be affixed by means of non-removable stainless steel fasteners.

2.10. GROUNDING

A. Provide two stainless steel external ground pads at diametrically opposite ends of the enclosure to facilitate connection of the enclosure to external ground wells.

B. Connect the ground bus provided in each piece of electrical equipment to the enclosure structural steel frame and to the external ground pads.

2.11. HEATING, VENTILATING, & AIR CONDITIONING (HVAC)

A. Provide wall-mounted packaged terminal air conditioning heat pump system to maintain the inside temperature of the enclosure not more than 85°F, with an outside ambient temperature of 90°F.

B. Provide PTAC with heat-pump capability to maintain the interior temperature of 70°F when the outside temperature is -15°F. Backup electric heat source is permitted if required and contained within the PTAC.

C. Provide fan, filter, motorized dampers, thermostat, and controls integral with each system.

2.12. ELECTRICAL REQUIREMENTS

A. Provide the enclosure with the following factory-installed electrical features:

1. Electrical distribution transformers and panelboards, as shown in the Drawings, completely pre-wired at the factory, with branch circuits serving enclosure interior and exterior lighting, convenience outlets, ventilation equipment, and other loads as indicated in the Drawings.

2. Interior lighting as shown in the Drawings.

3. Interior emergency lighting shall comprise 90-minute battery packs operating two wall-mounted battery-operated emergency lighting units, one near each door.

4. Duplex convenience outlets, NEMA 5-20R, as indicated on the Drawings.

2.13. AISLE MATTING

A. Provide electrical grade rubber matting on aisles in front of and between electrical switchgear.

2.14. LIFTING LUGS

A. Lifting lugs shall be provided with each shipping split along the enclosure base frame exterior. Lugs may be removable to reduce overall shipping size, however all hardware shall be included for handling at the site.

2.15. FLOOR CUTOUTS

A. Floor cutouts for conduit and cable entries and exits shall be provided with gasketed 12-gauge galvanized steel cover plates.

2.16. PAINTING OF WALL AND ROOF PANELS

A. Color finish wall covering and roof covering at the factory on both sides. Prepare surfaces for coating by thoroughly cleaning, pretreating, and priming (if required by the finish coat) to provide a film which is compatible with the metal surface and the color finish. Treat galvanized steel surfaces per DOD-P-15328D. Clean surfaces of oil, grease, loose scale, and other foreign substances. Prime coat shall be in accordance with the manufacturer's standard system.

B. Shop paint doors, and doorframes in the manufacturer's standard color.

C. Color finish shall consist of a synthetic resin base coating that has been plasticized and stabilized against heat and light with a thermosetting silicone topcoat.

D. Dry-film coating thickness of the color coat shall be not less than 1.0 mil for exterior and interior surface finish. The exterior and interior finishing systems shall meet the quality standards specified in The Aluminum Association publication, "Aluminum Standards and Data". Colors shall be as selected by Woodland Pulp from manufacturer's standard colors.

2.17. PAINTING OF GIRTS, PURLINS, BEAMS, AND COLUMNS

A. Coat the same as the wall and roof panels.

2.18. PAINTING OF DOORS, WINDOWS, AND LOUVERS

A. Coat doors with the same coating used on the wall and roof panels.

2.19. SEALANT

A. Provide sealant of the type recommended by the enclosure manufacturer at each joint.

2.20. SPARE PARTS

A. Provide a minimum of 5% excess over the required amount of nuts, bolts, screws, washers, and other required fasteners for field assembly of shipping splits with each enclosure.

PART 3 - EXECUTION

3.01. STORAGE AND PROTECTION

A. Receive delivery from the manufacturer of the electrical equipment enclosure. Store, handle, and erect the prefabricated enclosure, components, and other manufactured items such that they will not be damaged or deformed. Stock materials stored on the site before installation on platforms or pallets and cover with tarpaulins or other weathertight covering. Store panels so that water will drain off. Upon arrival on the jobsite, remove moisture on panels, restack, and protect until used.

3.02. INSTALLATION

A. Determine base anchorage before placing concrete footings, walls, or slabs to support the enclosure.

B. Install in accordance with the manufacturer’s instructions and drawings and the requirements herein. Keep exposed surfaces clean and free from sealant, metal cuttings, and other foreign materials.

C. Seal side laps and end laps of roof and wall covering and joints at accessories. Drive fasteners normal to the surface and to a uniform depth to properly seat the gasketed washers. Fasten accessories into framing members.

D. Insulate incompatible dissimilar materials, which are in contact by means of gaskets or insulating compounds.

3.03. INSTALLATION OF DOORS

A. Adjust doors so they operate smoothly without sticking or jamming.

3.04. FIELD PAINTING

A. Touch up factory-coated finish surfaces with the enclosure manufacturer’s touch-up paint for the particular finish coat used.

END OF SECTION

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SECTION 31 23 01

EARTHWORK AND ROCK EXCAVATION

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section consists of the following activities:

1. Provide all management, equipment, tools, labor, materials, and accessories to perform all preparation, measurements and survey, excavation, grading, proof-rolling, compaction, soil conditioning, earth handling, storage and disposal necessary for the Work. Establish all necessary controls for excavation safety and erosion and sedimentation management.

2. Rough grade and shim work areas at the site receiving new work under this Contract to create safe working platforms and transitions between abrupt grade changes. Manage excess cleared materials for reuse or off-site disposal; coordinate with Woodland Pulp.

3. Cut and completely remove any vegetation interfering with the proposed work.

4. Verify locations of all buried structures prior to any excavation or drilling, including contacting Woodland Pulp, DigSafe, and local authorities to mark buried utilities. Also retain the services of a ground penetrating radar specialty subcontractor to identify and mark locations of potentially conflicting underground structures.

5. Strip all topsoil and organic subsoil to its full depth, from areas receiving new construction, and areas to be re-graded; and stockpile the removed topsoil at a designated location on Woodland Pulp's property for potential reuse, as applicable.

6. Over-excavate all buried organic material, unacceptable fill material, disturbed natural material, and any other material identified by the Engineer to be unacceptable for temporary or permanent support of the new construction, as applicable.

7. Based upon a site benchmark identified by Woodland Pulp, identify and establish construction benchmarks in the field to set the correct elevations of and layout and excavate as required for the following:

   a. New concrete foundations, footings, piers, and slabs.

   b. New utility lines, utility structures, utility conduits, and for relocation of existing utility lines and utility structures.

c. New subgrades for the access roadway and for other non-specified site work.

d. Existing underground items designated on the Drawings to be removed.

e. Non-specified items for which accurate excavation is required.

8. Furnish, install, and maintain for duration of any period where soil instability may be present, sheet piling and/or other acceptable shoring, if necessary, to protect excavations against cave-in due to the earthwork performed under this Contract.

9. Proof-roll all disturbed and undisturbed surfaces which are to receive new foundations, footings, slabs, pavements, structural borrow, gravel base course, and other loadbearing elements, to ensure against any weak areas in the substrate.

10. Perform in a quality controlled manner all excavation subgrade filling and backfilling for exterior and interior work, including specified compaction thereof, and provide all specified borrow materials for such purposes, except as otherwise specified herein.

11. Perform all operations and provide such equipment and materials, as necessary, for proper erosion control around excavated areas.

12. Coordinate all work with Woodland Pulp and that of other trades.

1.02. REFERENCES

A. Work performed and material supplied under this Section shall conform to the requirements of the following specifications, latest edition. Requirements specifically enumerated in this Section or shown on the Drawings supersede the referenced specifications. In case of the disagreement between specifications, the more stringent requirements shall govern unless a written clarification is issued.

B. American Society for Testing and Materials International (ASTM):

1. C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

2. D422: Standard Test Method for Particle-Size Analysis of Soils.

3. D698: Laboratory Compaction Characteristics of Soil Using Standard Effort (Standard Proctor).

4. D1557: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

5. D2216: Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

C. Perform excavation work in compliance with applicable ordinance of governing authorities having jurisdiction including, but not limited to:

1. Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) Part 1926, Subpart P.

1.03. SITE CONDITIONS

A. Subsurface investigations have been performed for the Project. Geotechnical data on subsurface conditions observed in exploratory borings are presented in a Geotechnical Report provided as a Supplement B to these specifications and as boring logs shown on the Drawings.

B. Methods of construction pursued by the Contractor and its subcontractors shall be such as to ensure safe operation, the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. All work shall comply with all applicable Federal, State and local codes, laws, regulations and ordinances. The Contractor is solely responsible for maintaining safe working conditions at the construction site at all times.

C. Acceptance or rejection by the Engineer of temporary support of excavation shall not relieve the Contractor of any responsibility for the adequacy and safety of the excavation.

1.04. QUALITY ASSURANCE

A. Codes and Standards: Comply with all applicable local, State and Federal rules, regulations and ordinances concerning sloping of excavation, trenching, and safety of workers, including the latest OSHA requirements.

B. All subgrades shall be inspected and approved by the Engineer prior to placing fill or new concrete structures.

C. Borrow materials shall comply with this specification and be subject to initial testing and testing during installation by Maine DMR.

D. Borrow sources shall be selected that provide a consistent, adequate supply for the volumes anticipated by the project Work, including on-site materials identified for reuse. No borrow shall be placed prior to the written approval of material, locations, and methods by the Engineer. If the material on site from the Contractor’s source of borrow material is visually identified by the Engineer to be significantly different from the materials previously approved, the Contractor shall perform at no additional expense to Maine DMR, additional sieve and proctor testing on the materials as requested by the Engineer to verify compliance with this Section.

E. Use adequate numbers of personnel who are trained and experienced in the activities to be performed and who are completely familiar with the specified requirements and methods required for proper performance of the work in this Section.

F. Use equipment of adequate size, capacity, and quantity to accomplish the work of this Section in a safe and timely manner.

G. Place materials and manage materials placed to preserve their quality and the quality of underlying and adjacent materials.

H. Testing Service: The Contractor shall employ and pay for a qualified independent geotechnical testing laboratory to perform soil and compaction testing during earthwork operations. The Contractor will coordinate scheduling and provide necessary means to assure cooperation with the testing firm. Work and/or materials which are defective shall be repaired and re-tested at the Contractor's expense. Provide an electronic copy of independent soil and compaction testing to the Engineer.

1.05. QUALITY CONTROL

A. Provide adequate survey control to establish all lines and grade work not presently established at the site in accordance with the Drawings and Specifications. Establish permanent benchmarks necessary for the work under this Contract. Maintain all established bounds and benchmarks during the Work and replace as directed at no expense to Maine DMR any that are destroyed or disturbed.

B. Verify all locations, property lines, work lines, and other dimensioned points indicated on the Contract Drawings for the existing site.

C. Submit to the Engineer, a written confirmation of locations of all lines, and any discrepancies between conditions and locations as they actually exist and those indicated on the Contract Drawings.

1.06. WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32°F shall not be used as structural fill, embankment fill, or backfill until material has completely thawed.

B. Material excavated and exposed to excessive precipitation shall not be used as structural fill, embankment fill, or backfill until material has drained and dried sufficiently for use.

1.07. EXCAVATION SUPPORT

A. The Contractor shall provide suitable slopes, benches, and or support of excavation systems in accordance with the applicable regulations to provide safe excavations and means for egress. Dewatering structures erected for work with the river or tailrace shall conform to applicable requirements of Section 31 23 19 Water Control Measures.

1.08. DEWATERING

A. The Contractor shall maintain dewatered excavations throughout construction. Dewatering operations on the island are anticipated to be feasible through the use of open trenches and/or sumps and pumping. Dewatering of excavations within the river or tailrace shall conform to applicable requirements of Section 31 23 19 Water Control Measures.

1.09. PROTECTION

A. Comply with all safety requirements of Federal, State and local authorities, including OSHA.

B. Protect existing structures, pipelines, and facilities designated to be protected and any such facilities under construction during excavation. Damage to structures, facilities, and other items designated to be protected that resulted from the Contractor's excavation activities shall be repaired by the Contractor at no cost to Maine DMR and to the satisfaction of Woodland Pulp and the Engineer.

C. Protect existing trees, shrubs and other vegetation outside the limits of site disturbance.

D. Blasting will not be allowed for the excavation as required under these Specifications.

1.10. SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 01 33 00 and shall at a minimum include the following.

B. Temporary Excavation and Support Plan

1. Submit a Temporary Excavation and Support Plan (Plan) to the Engineer at least 21 calendar days prior to starting any onsite construction work for excavation(s) and temporary supports. If the Contractor purchases, rents, installs, or mobilizes to the site any elements of any temporary support systems prior to the Engineer's review and response to the submittal, it does so at its own risk, and will not be due any additional compensation from Maine DMR if such elements are not subsequently used.

2. The Plan shall include:

a. Drawings showing locations, dimensions, and relationships of elements and sequencing/staging of the proposed temporary excavation(s) and any proposed temporary support system(s).

b. Details regarding the type(s) of support system(s) and methods of excavation and support construction for both soil and rock excavation.

c. Design calculations and assumptions required to substantiate the Plan.

d. Proposed locations of stockpiled excavated material.

e. The minimum lateral distance from the crest of slopes for vehicles, equipment and stockpiled excavated materials.

f. Anticipated difficulties and proposed resolutions.

3. Design calculations and designs completed as part of the Plan shall be stamped, signed, and dated by the Contractor's professional engineer, and have demonstrated competence and experience in relevant aspects of geotechnical and structural engineering.

4. For temporary excavation(s), the Plan shall include, but not be limited to, plan and section drawings clearly showing the location, extent and orientation of excavation slopes and other excavation support measures, and sequencing/staging of excavations.

5. For any proposed temporary support system(s), the Plan shall include type, location, size, and arrangement of all elements of the system; include plan and section drawings and details as necessary to fully illustrate the proposed temporary support system(s). Submit data sheets for all materials proposed to be used for any temporary support system(s).

6. The Plan shall include a detailed description of the sequencing and coordination with other Work (including dewatering) of the temporary excavation and support work, including installation, maintenance, monitoring, and removal activities. The Plan shall also describe contingency activities to be undertaken in the event of unexpected performance issues associated with any excavation and/or shoring activities.

7. The Plan shall include an Erosion and Sediment Control Plan in coordination with Woodland Pulp and in compliance with the Contract Drawings and Section 01 57 13 Temporary Environmental Management that addresses sediment and erosion control measures and best management practices to protect downstream waterways.

8. Engineer review and response to the Plan proposed by the Contractor will only be with respect to the basic principles of the methods the Contractor intends to employ. Review of the Plan by the Engineer shall not relieve the Contractor of the full responsibility for the adequacy and safety of the temporary excavation(s) and support system(s).

9. If any aspect of the temporary excavation(s) or support system(s) is modified during installation or operation, revise or amend the appropriate drawings and calculations and resubmit the Plan for review by the Engineer.

C. Daily Shift Reports

1. Submit, in a form acceptable to the Engineer, complete daily shift report for the previous workday each morning by 10:00 am, with the following minimum information:

a. Type, location, and quantity of temporary support of excavation support installed.

b. Methods of excavation used and estimate volumes moved.

c. Description of ground behavior.

d. Crew size including identification of each employee by name, classification, and work assignment.

e. Water inflow quantities and removal methods.

f. Number and type of equipment used.

g. List of idle or inoperative equipment, times, durations, and reason for downtime.

h. Delay to work and reasons why.

i. Testing conducted and results.

j. Additional information required by the Engineer.

D. Borrow Material Testing by Contractor

1. Provide representative samples of borrow materials (5-gallon pail, minimum) taken from the source. Tag, label, and package the samples and deliver to a certified independent geotechnical testing laboratory. Provide access to the borrow site for field evaluation and inspection by the Engineer, if requested.

2. Provide sieve analysis (ASTM D422) from certified soils testing laboratory for all borrow materials and any materials from the site identified for reuse.

3. Provide modified Proctor analysis (ASTM D1557) from certified soils testing laboratory for all borrow materials and any materials from the site identified for reuse.

E. Certificates and Testing for the following:

1. Qualifications and certifications for the certified testing laboratory.

2. Subgrade inspection reports weekly, including verification that the soil conditions encountered and subgrade preparation performed. Provide index property values equal or superior to the requirements herein and as indicated on the Drawings.

3. In-place density tests for compacted fill and backfill, and re-compacted scarified native material weekly.

F. Product data: Submit manufacturer's product literature for geotextile fabric and other proposed products.

G. The Contractor shall be responsible for tests to ascertain that material proposed to be incorporated into the work meets the requirements of the Contract Documents. Acceptance or rejection of fill materials and compaction of fill will be based on the results of laboratory testing. Testing is to be performed by an independent testing laboratory and paid for by the Contractor.

PART 2 - MATERIALS

2.01. GEOSYNTHETICS

A. Geotextile fabric for use for soil separation shall be Mirafi 160N, or approved equal.

B. Geosynthetics used for subsurface stabilization should consist of Mirafi BXG Geogrid overlain by Mirafi 160N geotextile, or approved equals.

2.02. INSULATION

A. Insulation used as frost protection around foundations shall consist of a minimum 2-inch thick extruded polystyrene (XPS) rigid foam insulation such as Owens Corning FOAMULAR 250, or approved equal.

2.03. BORROW MATERIALS

A. General: All fill material must be clean and free from organic matter, roots, brush or other vegetation, trash, construction materials, debris, frozen material, rocks larger than 2 inches or unbroken lumps larger than 4 inches, obvious contamination, or other detrimental substances, and must be accepted by the Engineer prior to placement.

B. On-Site Materials: On-site soil meeting the requirements of Paragraph 2.03.C may be used as embankment fill or backfill in landscape areas, but shall not be used as fill or backfill below or adjacent to structures unless processed to meet the requirements of Paragraph 2.03.D.

C. Common Fill: Excavated inorganic, granular soil that is free of deleterious materials or other weak or compressible materials, and can be adequately compacted. The maximum particle size is recommended to be 6 inches, and no more than 30 percent by weight should pass the No. 200 sieve.

D. Structural Fill: May be imported or processed on-site material. In addition to the requirements of Paragraph 2.03.A above, structural fill shall meet the following requirements and be accepted by the Engineer:

Gradation	**Percent Finer by Weight**
6-inch	100
1-inch	60-100
No. 4 Sieve	35-85
No. 10 Sieve	25-75
No. 20 Sieve	15-60
No. 40 Sieve	10-45
No. 100 Sieve	5-25
No. 200 Sieve	3-10

Maximum 3-inch particle size within 12 inches of foundation and slab subgrade elevations.

E. Aggregate Base Course: Shall meet requirements of Maine DOT Type 703.10 Aggregate Type A and be accepted by the Engineer.

F. Crushed stone: Hard durable crushed stone, free of organic matter, in 3/4 inch minus gradation, except as otherwise indicated on the Drawings.

G. Lean Concrete Fill: Refer to Section 03 30 00 Cast-in-Place Concrete (Class B Concrete).

H. Flowfill: Refer to Section 03 30 00 Cast-in-Place Concrete.

2.04. CONFIRMATORY TESTING

A. All materials used as new fill to support the project objectives must be formally assessed for conformance with Paragraph 2.03. This may include regular visual examination of materials, field testing, and/or laboratory testing. The nature of testing efforts must be commensurate with the significance of the material being used as follows.

1. All materials shall be visually examined at least once a day to assess consistency and also confirm that their intended properties have not been adversely altered by site or environmental conditions. Significant changes noted must be addressed immediately by further testing or replacement/improvement of the materials. Maine DMR may collect its own sample of materials for independent testing at any time during the construction.

2. Structural Fill conformance testing must be performed prior to being delivered to the site and include gradation and proctor test data. During the work, additional gradation and proctor test data must be obtained any time that visual observation or unexplained compaction data warrant. At a minimum, additional gradation and proctor test data must be provided for every 2,500 cubic yards of material delivered to the site.

3. For Gravel Fill, Drainage Fill, and Pipe Bedding, conformance must be performed prior to being delivered to the site and include gradation and proctor test data. At a minimum, additional gradation and proctor test data must be provided for every 5,000 cubic yards of material delivered to the site.

4. For Crushed Stone and Common Fill, conformance assessments may be achieved by visual methods only. If during the work, visual assessments indicate abnormal gradation or obvious include of unacceptable materials, additional gradation and proctor test data must be obtained to document the condition and correction of the material must be achieved.

PART 3 - EXECUTION

3.01. GENERAL

A. Identify required excavation and fill lines, levels, contours and datum, as shown on the Drawings and as required to perform the Work.

B. Coordinate the work of this Section with the respective trades responsible for installing interfacing work, to assure that the excavation, backfilling, and filling work performed hereunder is acceptable to such trades for the installation of their work.

C. Any damage to the Work caused by the Contractor's operations, including disturbance of the material beyond the required excavation, shall be repaired by the Contractor at no additional cost to Maine DMR. Removal of materials beyond the indicated subgrade elevations, without authorization from the Engineer or Maine DMR, shall be classified as unauthorized and shall be performed at no additional cost to Maine DMR. Lean concrete fill may be used to bring elevations to proper positions, only when acceptable to the Engineer.

D. All repairs shall be as required by the Engineer.

E. The Contractor shall assume all responsibility for deductions and conclusions as to the nature of the materials to be excavated and the difficulties of making and maintaining the required excavations.

F. The Contractor shall take all necessary precautions to preserve the material below and beyond the established lines of all excavation. Any damage to the Work or the foundations due to the Contractor's operations shall be repaired as directed by the Engineer at the expense of and by the Contractor.

G. Protect existing surface and subsurface features on site and adjacent to site as follows:

1. Protect and maintain benchmarks, monuments or other established reference points and property corners. If disturbed or destroyed, replace at Contractor’s expense as accepted by Woodland Pulp and the Engineer.

2. Verify location and existence of utilities. Omission or inclusion of utility items does not constitute non-existence or definite location, respectively. Secure and examine local utility records for location data.

   a. Take necessary precautions to protect existing utilities from damage due to any construction activity. Repair damages to utility items as a result of Contractor activities at Contractor’s expense.

   b. Active Utilities: Do not interrupt existing utilities serving facilities and adjacent properties, except when permitted in writing by Woodland Pulp or local utility company, and then only after acceptable temporary utility services have been provided. Remove or relocate utilities only as indicated or specified.

   c. Inactive Utilities: Report inactive or abandoned utilities encountered in excavating or grading operations, and remove, plug, or cap as required. In the absence of specific requirements, plug or cap such utility lines as required by local rules or regulations.

3. Maintain existing structures free of damage. Any damaged items shall be repaired to original condition and to Woodland Pulp’s requirements at Contractor’s expense.

4. Provide full access to facilities, premises, roadways, and other points to prevent interruption of travel or access for operations or maintenance.

5. Maintain stockpiles and excavation in such a manner to prevent inconvenience or damage to structures on site, coordinate with Woodland Pulp.

6. Avoid surcharge or excavation procedures which can result in heaving, caving, or slides.

H. Protection of Structures: Prevent new and existing structures from becoming damaged due to construction operations. Prevent subgrade under new and existing foundations from becoming submerged or undermined during construction due to presence of surface or subsurface water or due to construction operations.

I. Dust Control: Employ all methods required to effectively control dust created by the work of this Section in accordance with the requirements of Section 01 50 00 Temporary Facilities.

J. Unanticipated Conditions: Notify the Engineer immediately upon finding evidence of obstructions, unsuitable subgrade materials below designated excavation elevations, or other conditions which are not shown or which cannot be reasonably assumed from existing surveys and project documents. Obtain Engineer's written instruction before proceeding with further work in such areas.

K. During excavation, the Contractor will be responsible for maintaining safe, stable excavation slopes in accordance with all regulatory agency requirements.

3.02. DRAINAGE AND DEWATERING

A. Upon entering the premises, assume responsibility for site and subsurface drainage and maintain such drainage during the duration of this Contract in a manner acceptable to the Engineer, at all times protecting and maintaining the existing conditions in adjacent areas.

B. Legally remove by pumping, draining or bailing all water which may accumulate or be found on the site within the Contract limits where excavation and grading are to be done and such water may adversely impact the work. Excavate, construct, and maintain all pump wells, sumps, dams, swales, channel, slopes or other necessary works to keep excavation areas clear of accumulated water. Newly-constructed and existing concrete and masonry shall be protected from injury resulting from de-watering work by the use of canvas, tarpaulins, or by such other sufficient method as the Engineer may approve.

C. Maintain at all times upon the worksite sufficient and satisfactory pumping machinery, including standby equipment. Provide pump wells or well points and underdrains as may be required, where needed to properly handle the water. Maintain excavations free from water until all backfilling operations and new construction has been completed. The Contractor shall maintain groundwater at least 2 feet below excavation subgrades, or at the top of prepared bedrock surfaces.

D. Where soil subgrades will be potentially exposed to precipitation place a thin layer of crushed stone (not more than four inches thick) along the bottom of the subgrade to provide a working surface and facilitate drainage of water. Combined layers of stone shall not exceed a thickness greater than 18 inches unless approved by the Engineer. Crushed stone greater than 12 inches in thickness that is place below the water table must be wrapped with a non-woven filter fabric. Alternatively, a thin (2 to 3 inch) layer of weak concrete may also be placed as a mud slab on exposed subgrade surfaces provide they are stable during placement of the concrete.

E. Water from excavations shall be disposed of in such a manner that will not cause injury to the environment and/or public health or negatively impact existing features or completed work. Under no circumstances place concrete, place borrow, or install appurtenances in excavations containing free water.

3.03. EROSION CONTROL

A. Starting with the clearing and grubbing operations performed hereunder, and continuing until final project closeout and restoration, institute erosion control measures in accordance with Section 01 57 13 Temporary Environmental Management to prevent migration of sediment from the work areas by wind, water, or machinery.

3.04. STRIPPING

A. Strip topsoil and organic subsoil to its entire depth from all areas which will be excavated, areas to be regraded, and from other areas where new construction would otherwise disturb the existing ground surfaces. Minimize mixing of organic soil with inorganic soil to preserve ability of organic soil to support new growth of vegetation when and if reused. Remove all clay deposits, large stones, peat, roots, and other objectionable matter from the topsoil, and stockpile the stripped topsoil on site for potential reuse, if and as directed. Protect the stockpile, as necessary, from erosion by wind and water.

3.05. EXCAVATION SAFETY

A. Provide sloping, shoring, sheeting and/or bracing at excavations, as required, to assure complete safety against collapse of earth at excavation side and end walls. Dewatering structures erected for work with the river or tailrace shall conform to applicable requirements of Section 31 23 19 Water Control Measures.

B. Comply with local safety regulations or in the absence thereof, with the provisions of the Manual of Accident Prevention in Construction of the Associated General Contractors of America, Inc., as well as the safety regulations of OSHA, including having a Competent Person on site to evaluate sidewall stability conditions, as necessary.

C. Remove sheeting and shoring as backfilling operations progress, taking all necessary precautions to prevent collapse of excavation sides. Where sheeting is required to be left permanently in place due to unanticipated conditions, approval from the Engineer must be obtained and an appropriate adjustment to the Contract price will be made.

D. The depth and locations of areas to be excavated may have the potential to adversely impact adjacent existing foundations. The Contractor must take precautions during excavation and subgrade preparation activities to ensure that the integrity of the existing foundation and stability of existing bearing soils are maintained at all times. In particular, measures must be used to prevent undermining of any footings and any loss of strength to subgrades for existing foundations, footings, slabs, utilities and other loadbearing elements that might be identified.

3.06. EXCAVATION

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish the Work.

B. Minimize disturbance to native soils at the bottom of excavations.

C. Excavation shall have support system(s) conforming to the requirements of Paragraph 3.05.

D. Excavations shall be completed in the dry. It is anticipated that this can be accomplished through a combination of cofferdams and flow diversion within the river.

E. The Contractor is responsible for maintaining safe excavation slopes at all times and for all conditions, in accordance with OSHA regulations and standards.

F. Size excavations to allow for support systems, forms, working space, granular base, filter and drain materials, structure backfill, topsoil, and similar items, where applicable.

G. Trim to neat lines where concrete is to be placed against foundation material.

H. Do not operate excavation equipment within 5 feet of existing structures or newly completed construction. Unless permitted by the Engineer, excavate by manual means in these areas.

I. Excavations for foundations shall be observed by the Engineer to verify that any uncontrolled manmade fill, loose, soft or otherwise undesirable materials are removed and that the footings will be on suitable prepared subgrade. At the time of such observation, it may be necessary for the Engineer to make hand auger borings and/or use a hand penetration device in the base of the foundation excavation to confirm that the soils below the base are satisfactory for foundation support. The necessary depth of penetration will be established during observation.

J. After the required excavation has been completed, the Engineer will observe the exposed subgrade to determine the need for additional excavation, if any. It is the intent that over-excavation is to be conducted in all areas within the influence of structures where unacceptable subgrade material exists at the exposed subgrade. Over-excavation shall include the removal of all such unacceptable material that exists directly beneath the structure or within a zone outside and below the structure defined by a line sloping at 1H:1V outside the edge of the footing. Backfill the over-excavated areas with structural backfill material in accordance with Paragraph 3.10.

K. Where the Engineer determines that foundation material is unsuitable through no fault of the Contractor, additional excavation and backfill will be ordered in writing. The Contractor will not be compensated for areas over-excavated without written authorization from the Engineer. Such areas shall be backfilled to the proper grade and limits shown on the Drawings in accordance with Paragraph 3.10.

L. If soft/loose pockets or undesirable materials are encountered in the excavation at the bottom of footing elevation, the proposed bottom of footing elevation may be re-established by backfilling after the unsatisfactory material has been removed with structural fill in accordance with Paragraph 3.10.

M. Soils exposed in the base of foundation excavations, including subgrade and/or structural fill, shall be prepared and compacted in accordance with Paragraphs 3.09. and 3.10., respectively, and shall be protected against any detrimental change in conditions such as disturbance from rain and freezing.

N. Maintain excavations free of water until after structures have been cured and backfilled.

1. Dewater excavations below the groundwater elevation and control water in accordance with Paragraph 3.02.

2. Surface runoff water shall be directed or drained away from the excavation and not allowed to pond. Take measures to provide protection from surface runoff entering the excavation areas. Examples include constructing berms and grading the area at the top of excavation slopes to drain away from the excavated area.

O. Place foundations as soon as possible after excavation is completed, inspected, and approved.

1. Until concrete or fill material is placed, protect approved subgrade from becoming loose, submerged, or soft.

2. If subgrade becomes loose, submerged, or soft before the structure or backfill is placed thereon, remove unacceptable material and replace with accepted compacted material or place geotextile fabric as directed by Engineer.

3.07. ROCK EXCAVATION

A. Refer to the boring logs on the Drawings for description of the rock conditions encountered.

B. The condition of the bearing surfaces and the excavated faces will be dependent on the method of excavation. An excavator equipped with a ripping tooth or a pneumatic hammer in conjunction with line drilling will likely be sufficient to excavate the rock on site, as the near-surface bedrock is generally expected to be weathered/highly fractured.

C. The use of line drilling should be used where necessary to create a relatively clean face and prevent overbreak, given the close proximity of the excavations to the existing structures.

D. The Contractor is fully responsible for the safe execution of the excavation including potential of damage to the existing Woodland Pulp facilities and/or disruption to operations.

E. Blasting shall not be used due to the proximity of the proposed excavations to the existing dam and powerhouse.

F. Rock excavations should be completed to create a relatively horizontal surface without any open faces, and care should be taken to prevent overbreak beneath the footing bearing elevation.

3.08. STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as structural fill, fill, or backfill until material is needed. Materials that are deemed suitable by the Engineer for structural fill, fill, or backfill shall be stockpiled separately from each other and from other materials.

B. Confine stockpiles to within areas approved by Woodland Pulp. Do not obstruct roads, facilities, or other ongoing work in the area.

C. Do not stockpile excavated material adjacent to excavations unless excavation side slopes and excavation support systems are designed by the contractor's engineer, constructed, and maintained for stockpile surcharge loads.

D. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work unless otherwise allowed by Woodland Pulp.

3.09. SUBGRADE PREPARATION

A. Clear, grub, and strip area to receive fill in accordance with Paragraph 3.04.

B. Excavate as required in accordance with Paragraph 3.06and 3.07.

C. Obtain inspection and approval of the prepared subgrade by Engineer prior to proceeding with foundation construction.

D. Prior to placing concrete footings on bedrock, the bedrock surface shall be cleaned using high-pressure air or water to remove all soil and loose, decomposed, highly weathered and fractured bedrock and approved by the Engineer.

E. If exposed, the bearing condition of the existing structures should be evaluated and protected, if necessary, to limit undermining during preparation of the bearing surface for new and existing footings.

F. If the exposed bedrock surface is steeper than 5 horizontal to 1 vertical (5H:1V), then anchoring, doweling, benching or other means should be employed to improve sliding resistance. Notify Engineer if this condition is encountered.

G. Subgrades should be aggressively proof-rolled with at least six passes (three each way in perpendicular directions) of a minimum 10-ton vibratory roller in open areas, or a 1-ton vibratory roller or large plate compactor in trenches. During the proof-rolling process, the subgrades should be reviewed to identify soft or unstable areas. Unsuitable areas (e.g., high fines, saturated soils, and organics) should be over-excavated to more competent material and be replaced with compacted structural fill, as described in Paragraph 3.06. Where exposed native soils are observed to be saturated, proof-rolling should not include the use of vibration.

3.10. FILL PLACEMENT

A. Provide approved fill material. Do not place material in layers greater than 12-inches loose thickness where compacted self-propelled vibratory rollers, nor 8 inches where compacted by hand-operated vibratory plate compactors.

B. Soil materials used as backfill for should be compacted in lifts to 95 percent of maximum dry density +/- 3% of optimum moisture content in accordance with ASTM D1557 (Modified Proctor).

C. Place layers horizontally and compact each layer in a methodical and consistent manner. Achieve the property compaction of each layer prior to placing additional fill. Control moisture for each layer as necessary to meet requirements of compaction.

D. All fill material shall be placed and compacted "in-the-dry". The Contractor shall dewater excavated areas as required to perform the work and in such a manner as to preserve the undisturbed state of existing soil subgrades.

E. The Contractor shall not place a layer of compacted fill on snow, ice or soil that was permitted to freeze prior to compaction. Removal of these unsatisfactory materials will be required as directed by the Engineer, at no additional expense to Maine DMR.

F. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of a day's operation. Prior to terminating operations for the day, the final layer of fill, after compaction shall be rolled with a hand operated compactor or a smooth-wheeled roller to eliminate ridges of soil left by tractors, trucks and compaction equipment.

G. Do not start backfilling until concrete forms have been removed, construction debris and trash removed from excavations, concrete finishing has been completed.

H. Do not backfill against walls or other earth retaining structures until concrete has reached specified 28-day compressive strength and all load bearing supports, upper slabs, and footings are in place and cured to specified 28-day compressive strength.

I. Place fill evenly on all sides of grade beams, walls, and structures or provide bracing.

J. Flowfill may be used for structure backfill as approved by the Engineer. Where Flowfill is placed against only one side of a foundation, wall, bulkhead, or other structure, and no lateral earth pressures are applied to the opposing side, provide bracing to resist the pressure imposed. Place in lifts not greater than 3-feet and allow to cure, until flowfill is no longer plastic prior to placing next lift to avoid imposing excessive lateral loads on structure or bulkhead.

3.11. DISPOSAL OF EXCESS SPOIL AND WASTE MATERIALS

A. Remove waste materials daily, including materials not allowed for fill or backfill, trash, and debris, and properly dispose of off Woodland Pulp's property.

3.12. FIELD QUALITY CONTROL

A. All subgrades shall be approved by the Engineer prior to placing concrete structures and/or soil backfill.

B. During the placement of any materials that will be structurally significant, a representative number of in-place field density tests must be performed. This shall apply to compacted structural borrow below slabs, foundations, pavements, pads, and aprons, and also including backfill of select material against structures for lateral support and installation of fill used to construct new slopes.

C. The minimum number of compaction tests in each lift of structural fill or backfill shall adhere to the frequencies described in the table below.

Recommended Field Density Test Frequencies	
Area	**Recommended Minimum Density Test Frequency**
Individual Column Footings	One test per 50 sf per lift of structural fill
Continuous (Strip) Footings	One test per 50 lineal feet per lift of structural fill
Roadway Subgrade Soils	One test per 10,000 sf of compacted existing soils and in each lift of structural fill
Foundation Backfill	One test per 50 cy of fill

D. If, in the opinion of the Engineer based on the report of testing and inspections, the subgrade or backfill has been placed at less than the required density, additional compaction and testing shall be provided at no additional expense to Maine DMR.

END OF SECTION

SECTION 31 23 19

WATER CONTROL MEASURES

PART 1 - GENERAL

1.01. DESCRIPTION

A. The work includes designing, installing, maintaining, and later removing temporary bulkheads, stop logs, cofferdams, and other temporary structures and pumping systems.

B. The purpose of the dewatering structures is to allow construction of project structures under dry conditions, which might otherwise be submerged. All construction work which forms a part of the permanent project structures shall be done in areas free from water unless otherwise authorized in writing by the Engineer.

C. When no longer required for the intended purposes, the Contractor shall remove all temporary dewatering structures, construction, and equipment and shall leave the work areas in neat and orderly condition. All materials and equipment removed shall be disposed of where designated by Woodland Pulp and Maine DMR. No temporary construction materials will be permitted to remain or be spoiled in the bottom of any body of water.

D. Woodland Pulp shall be informed prior to installation of any dewatering structures. Removal of dewatering structures shall not begin until Woodland Pulp and Maine DMR's approval of the completed work is obtained.

E. The Contractor shall comply with all local, state, and federal rules and regulations. The Contractor shall also be in compliance with the Maine DEP and U.S. Army Corps of Engineers.

1.02. RESPONSIBILITY FOR DEWATERING STRUCTURES

A. The Contractor shall be fully and solely responsible for the structural design, adequacy, safe construction, maintenance, repair, removal, and disposal of all dewatering structures and related facilities required for protecting the work to river elevations. If water elevations increase to the extent that the dewatering structures are overtopped and construction areas are flooded, Woodland Pulp and Maine DMR will assume no responsibility for costs, delays, or damages from overtopping.

B. The Contract Drawings and permit application are based on an earthfill cofferdam because that is viewed as the most conservative option regarding permits. The Engineer is not directing or requiring the use of an earthfill cofferdam. The cofferdam system(s) shall be selected by the Contractor and reviewed by Woodland Pulp, Maine DMR, and the Engineer.

C. The Contractor shall perform all concrete work behind the bulkhead/cofferdam free from water. Provide, furnish, install, maintain, and operate all necessary diversions, pumping and other equipment or methods necessary for dewatering the work area.

D. The Contractor shall be responsible for providing any and all power, equipment, and labor needed to dewater the work area, including pumps, hoses, etc.

E. All dewatering equipment shall be in first-class condition and shall at all times be maintained and operated at the efficiency and capacity necessary for maintaining the area behind the bulkhead free from standing water or wet conditions that prevent proper construction.

F. Contractor shall provide dewatering facilities with stand-by pumps with 100 percent standby capacity.

G. Woodland Pulp will attempt to cooperate with the Contractor to control water levels in the area of the work as far as practical and within the regulatory limitations and mill operations.

H. The Contractor shall comply with all applicable environmental regulations during operation of the water control systems.

1.03. HYDROLOGICAL INFORMATION

A. The following tables are flood data and flow data for the site (per the FEMA 2007 Flood Insurance Study and 2023 Alden Water level Study):

Return Period (Years)	Approx. Site Flow (cfs)
10	19,400
50	26,900
100	30,300

Return Period (Years)	Approx. Headpond El. (ft)	Approx. Tailwater El. (ft)
10	145.5	105.5
50	145.9	108
100	146.0	109

All elevations are based on NAVD88.

The headpond levels are highly regulated by use of the spillway and Tainter gates. This results in there being no clear correlation between headpond level and river flow. Without the ability to develop a true rating curve, best professional judgement was used to define the high and low headpond levels that correspond with the FEMA flood flows.

Woodland flood of record: 24,100 cfs, May 1923.

B. The existing station has a hydraulic capacity of approximately 3,200 cfs.

C. Monthly flow duration curves are attached. The flow at 50% exceedance is the mean monthly flow. Spillway rating curve and tailwater data plots are also attached. It is the Contractor's responsibility to analyze this information to assess the probability of a specific water level being exceeded.

D. High flows can occur in any month. The cofferdam design must incorporate this possibility.

1.04. DESIGN CRITERIA

A. The elevations of cofferdam shall be proposed by the Contractor and reviewed by Woodland Pulp, Maine DMR, and the Engineer, balancing risk versus costs.

B. All cofferdam steel structures shall be designed, fabricated, and installed in accordance with the AISC 325-"Manual of Steel Construction, 15th Edition."

1.05. ADDITIONAL CRITERIA

A. The Contractor shall submit a general arrangement plan including sections and elevations sufficient for determining the volume of fill (earth or concrete) required and the volume of water to be removed from within the dewatered area.

B. The Contractor shall submit design details and calculations for review by Woodland Pulp, Maine DMR, and the Engineer. The cofferdam calculations and design drawings shall be stamped by a professional engineer hired by the Contractor.

C. If earthfill is used for the cofferdam construction, then the fill must be granular fill. Bank run gravel is acceptable if there is less than 10 percent fines.

D. Geotechnical information and survey data are included as supplements to these Specifications.

1.06. EMERGENCY ACTION PLAN AND WARNING SYSTEM

A. The Contractor must install and rehearse the established Temporary Construction Emergency Action Plan (TCEAP).

B. The Temporary Construction Emergency Action Plan will include the following items:

1. A warning system to be installed by the Contractor to alert workers of dangerous or impending conditions in sufficient time to evacuate the site.

2. Any construction personnel working around water will be required to wear life jackets. Life rings will be located immediately around the dewatering structure and will remain in place for the duration of the construction period. The life rings will be used only in the event of an emergency situation. The Contractor shall have boats available and easily and quickly launchable for any water related rescue required.

3. The Contractor will be required to hold an informal and document formal safety meetings, prior to initiating any construction activity, to inform workers of the actions to be followed should any of the alarms be activated. The workers will be instructed to exit the work area via one of the several routes from the work area and will be informed of the “safe areas”, which areas are providing maximum safety for workers.

4. In case of an emergency, the construction superintendent will be responsible for immediately notifying the appropriate personnel and emergency response organizations.

5. A designated individual shall be responsible for coordinating the safety program and rescue operations.

6. Other State or Federal OSHA-required equipment, or any equipment or procedures which will enhance and improve the overall safety of the Contractor’s or Woodland Pulp’s personnel.

7. None of the above shall be constructed to imply that Woodland Pulp, Maine DMR, or the Engineer assume responsibility for the Contractor’s safety measures.

1.07. DEWATERING SCHEME & MATERIALS SUBMITTALS

A. Construction Submittal: At least 30 days prior to start of the cofferdam or bulkhead construction, the Contractor shall submit to Woodland Pulp, Maine DMR, and the Engineer for review:

1. Detailed descriptions of the cofferdam or bulkhead systems.

2. Sequential steps of the diversion scheme.

3. Identify materials used, including fill material.

B. Plans shall be in sufficient detail to permit review of hydraulic conditions and stability of structures, including the stability if overtopped.

C. Plans shall show the method and equipment proposed for dewatering and maintaining the dewatered areas.

D. Dewatering plan shall include details for discharging dewatering water and measures for monitoring and limiting turbidity.

E. A review by Woodland Pulp, Maine DMR, and the Engineer of the Contractor's plans and/or comments on them will in no way relieve the Contractor of responsibility as stated above.

F. All cofferdam drawings and calculations shall be stamped by a registered professional engineer experienced in this type of construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01. PROPOSED CONSTRUCTION SEQUNCE AND CRITERIA

A. The sequence and duration of the cofferdam shall be proposed by the Contractor to most efficiently complete the work and minimize any environmental impact.

3.02. GENERAL

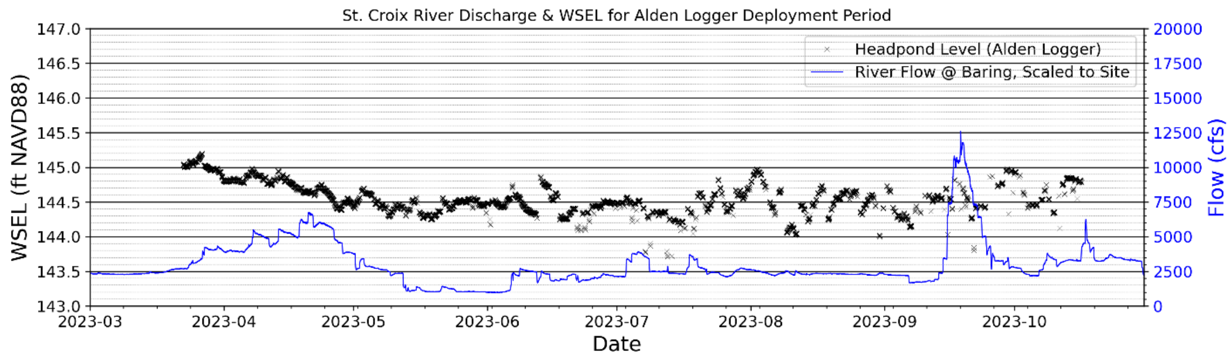
A. The Contractor shall at all times during construction, provide ample means and devices to remove promptly and dispose of properly all water entering excavations and keep the bottoms of the excavations firm and free of standing water.

B. The Contractor shall not allow discharged water to cause siltation, erosion, flooding, or other negative environmental impact on natural waterways or other property; such discharge shall be in accordance with applicable Federal, State, and local regulations. At dewatering discharge locations, sediment ponds, hay bales, silt barriers or other control measures shall be installed as necessary to control and prevent siltation.

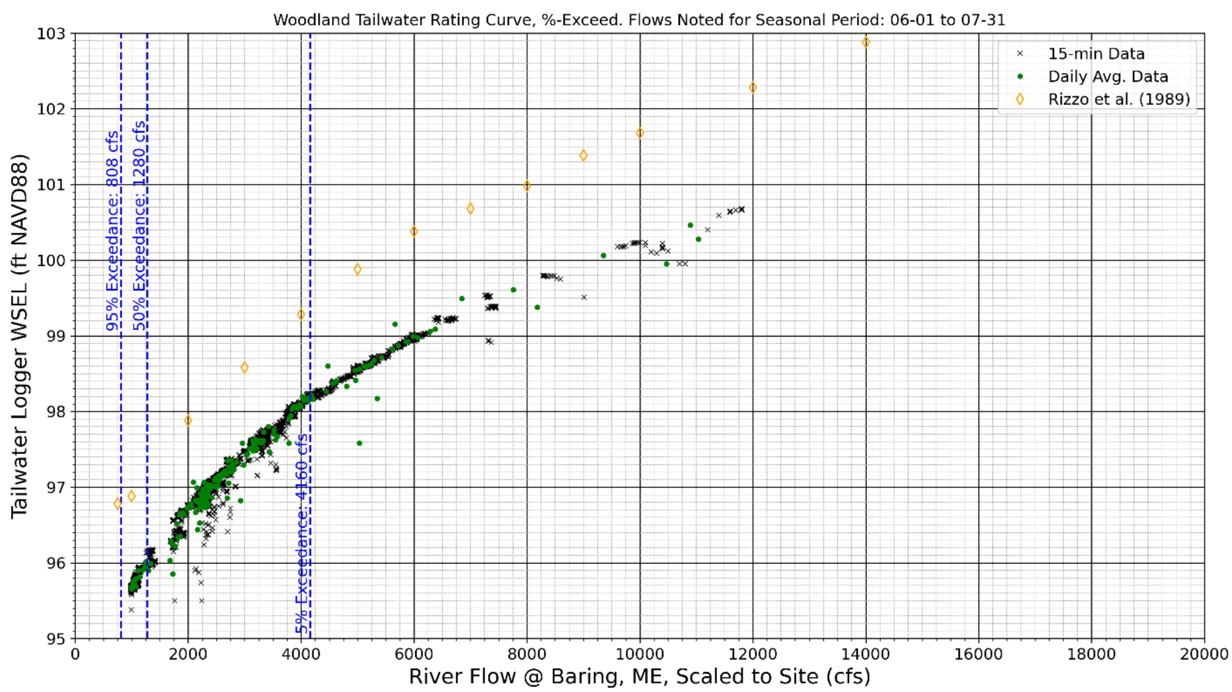
C. The Contractor shall operate water control systems continuously, including weekends and holidays and during Work stoppages, as necessary to prevent flotation of partially installed piping or structures, and prevent any other surface or groundwater related damage to structures, facilities, subgrades, slopes, or other Work.

D. The Contractor shall remove all elements of water control systems from the site at the completion of the Work.

HEAD POND AND TAILWATER CURVES

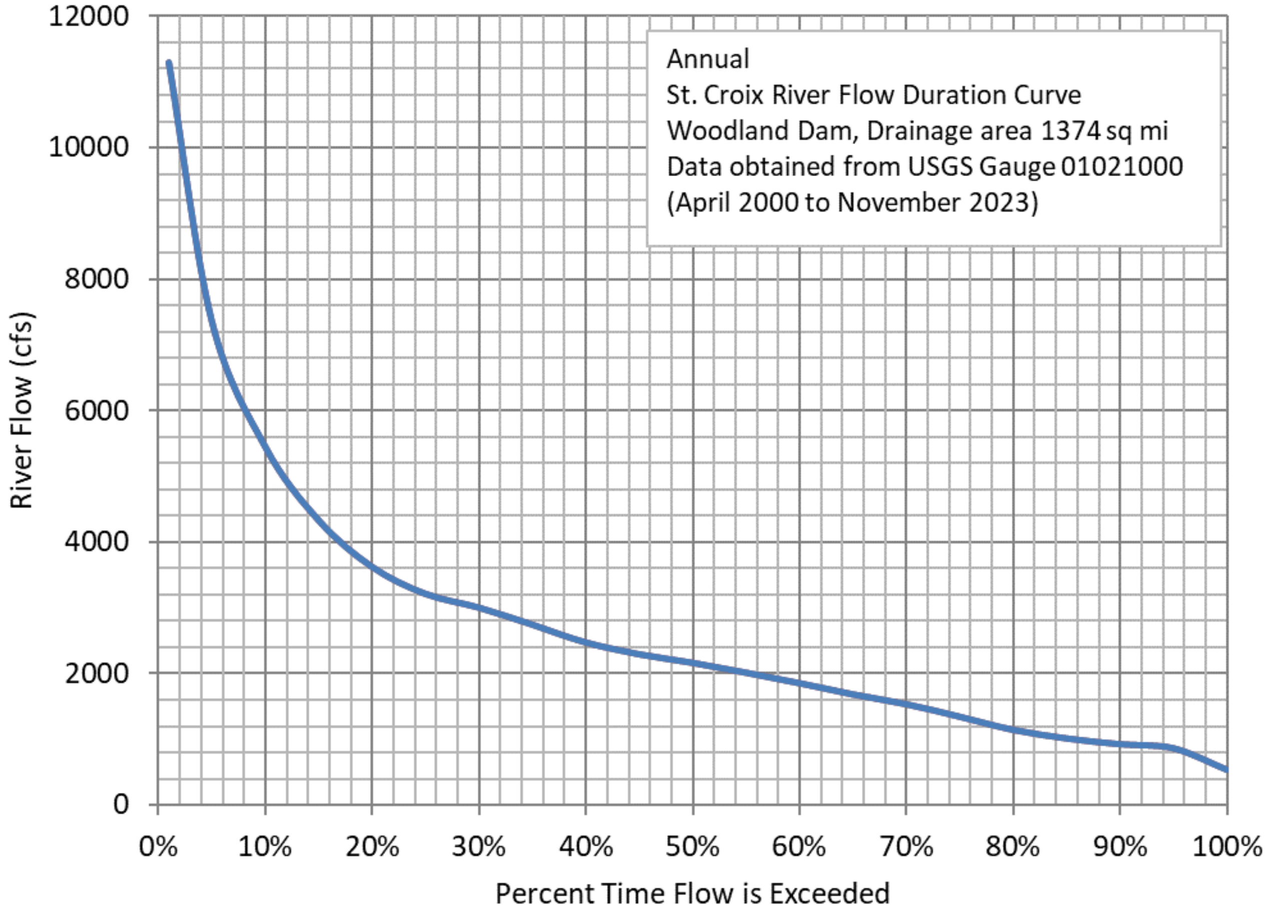


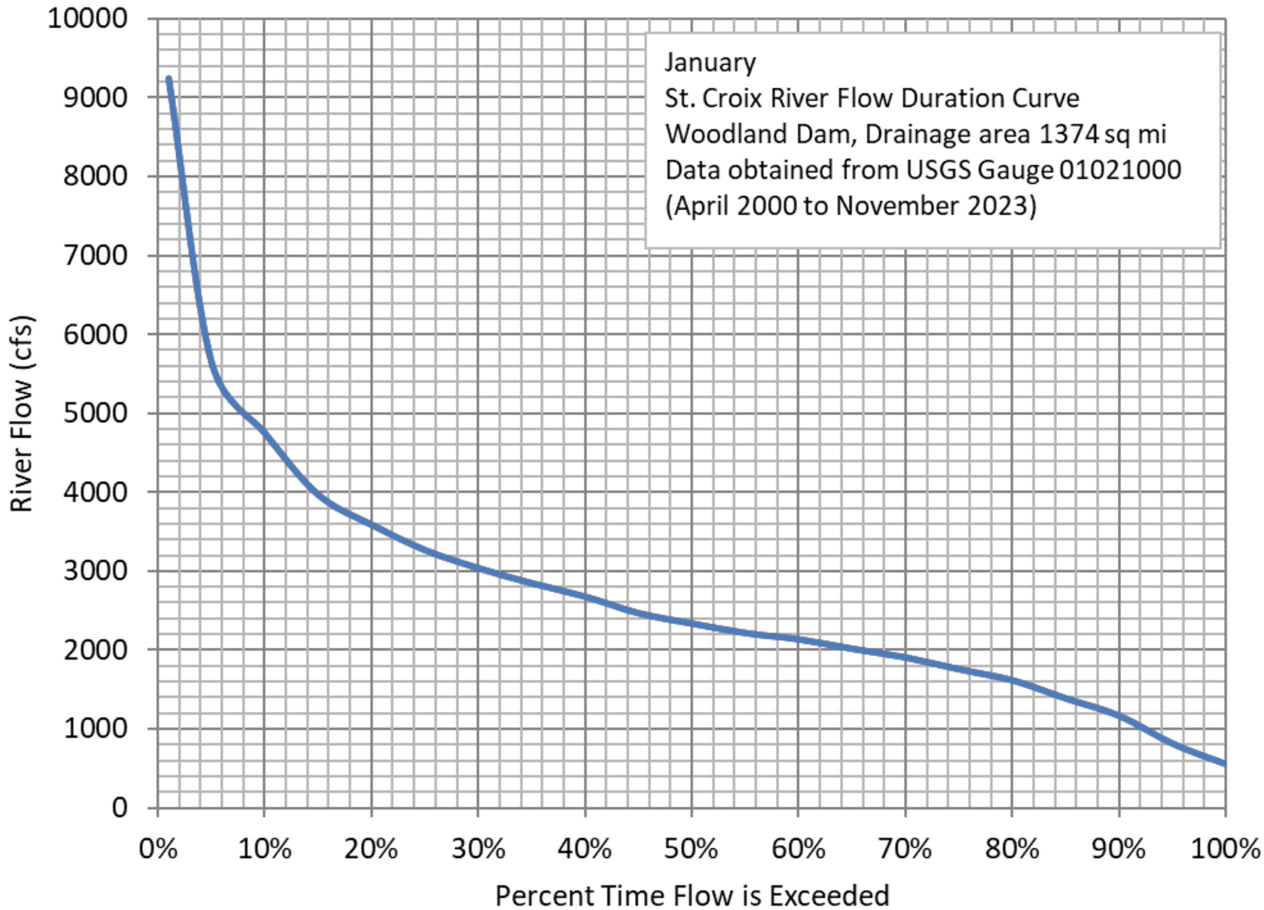
HEAD POND DATA (ALDEN ANALYSIS SHOWING NO CORELATION BETWEEN FLOW AND HEADPOND LEVEL SHOWING HEADPOND LEVEL IS CONTROLLED BY USE OF GATES)



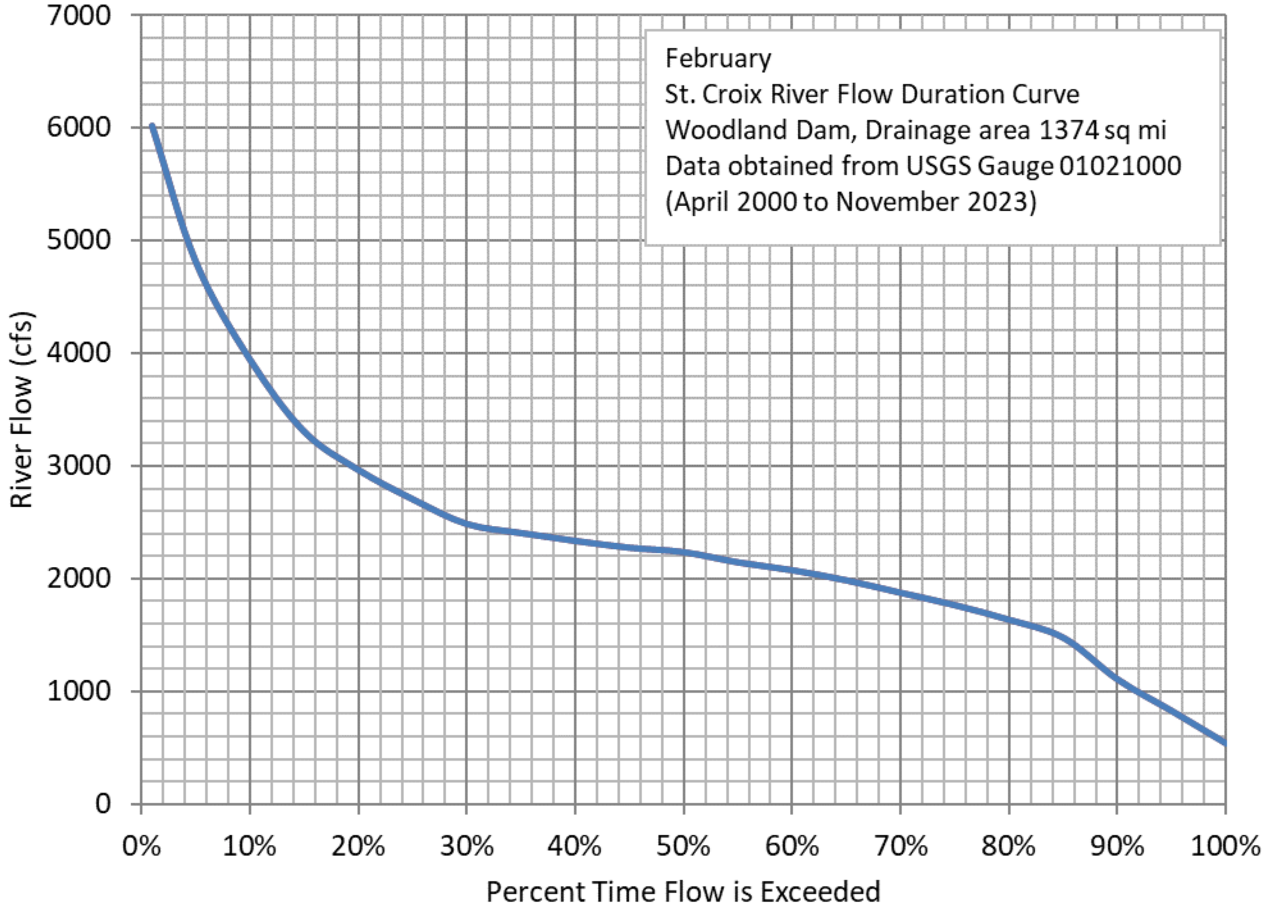
TAILWATER RATING CURVE (ALDEN ANALYSIS WITH EXCEEDANCE FLOWS FOR THE SEASONAL PERIOD 6-01 THROUGH 7-31)

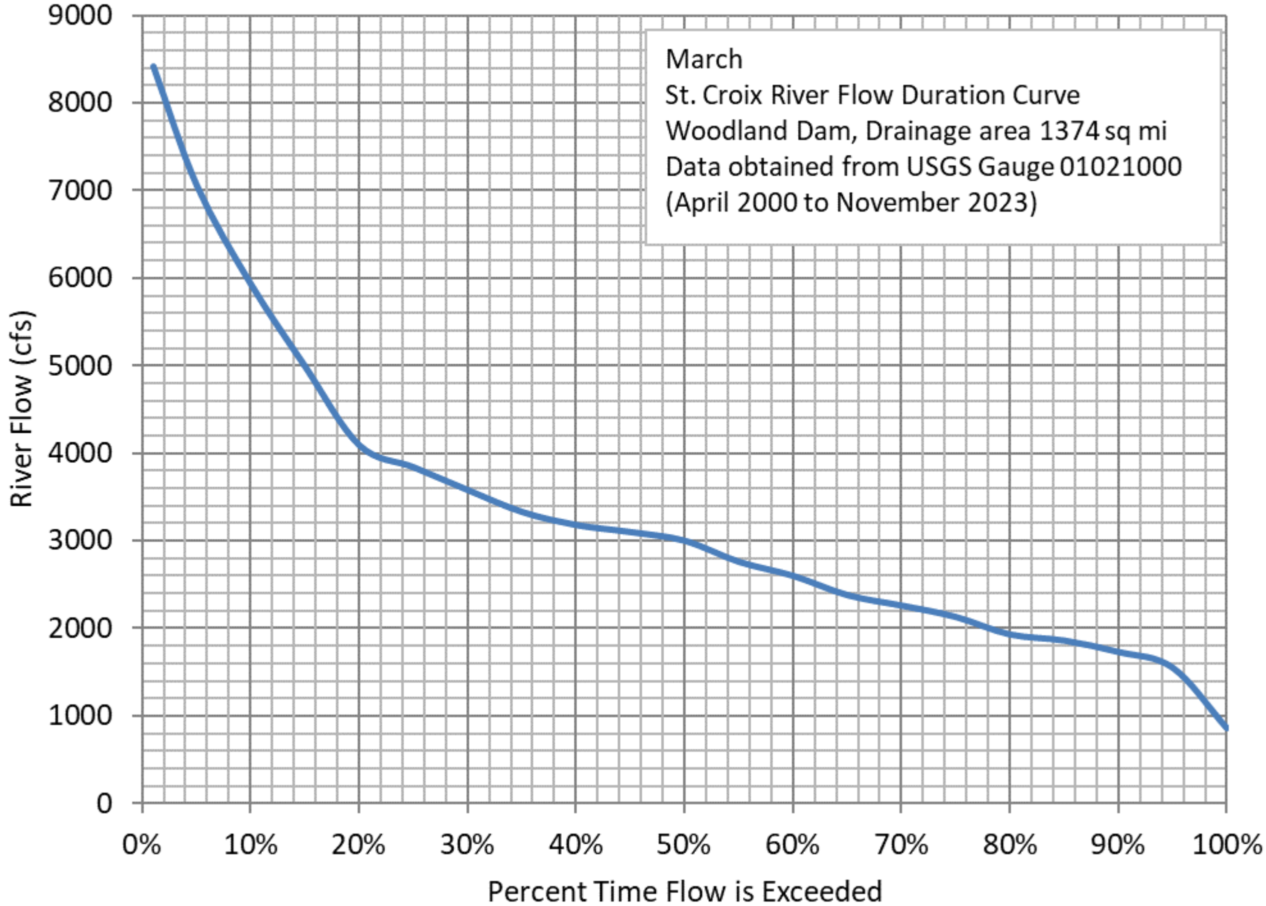
FLOW DURATION CURVES


Annual
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
12000
10000
8000
6000
4000
2000
0
River Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded



January
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


February
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


March
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
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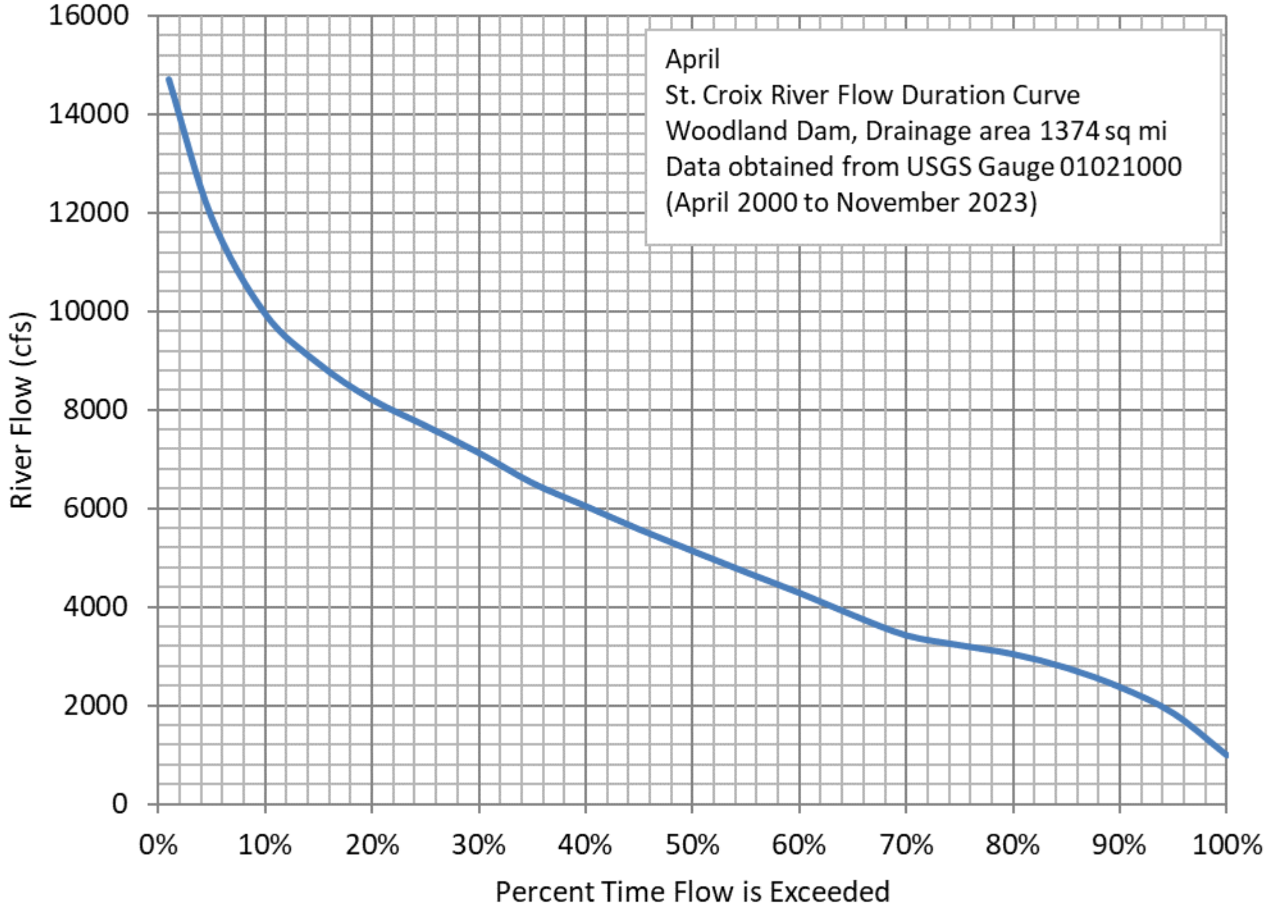
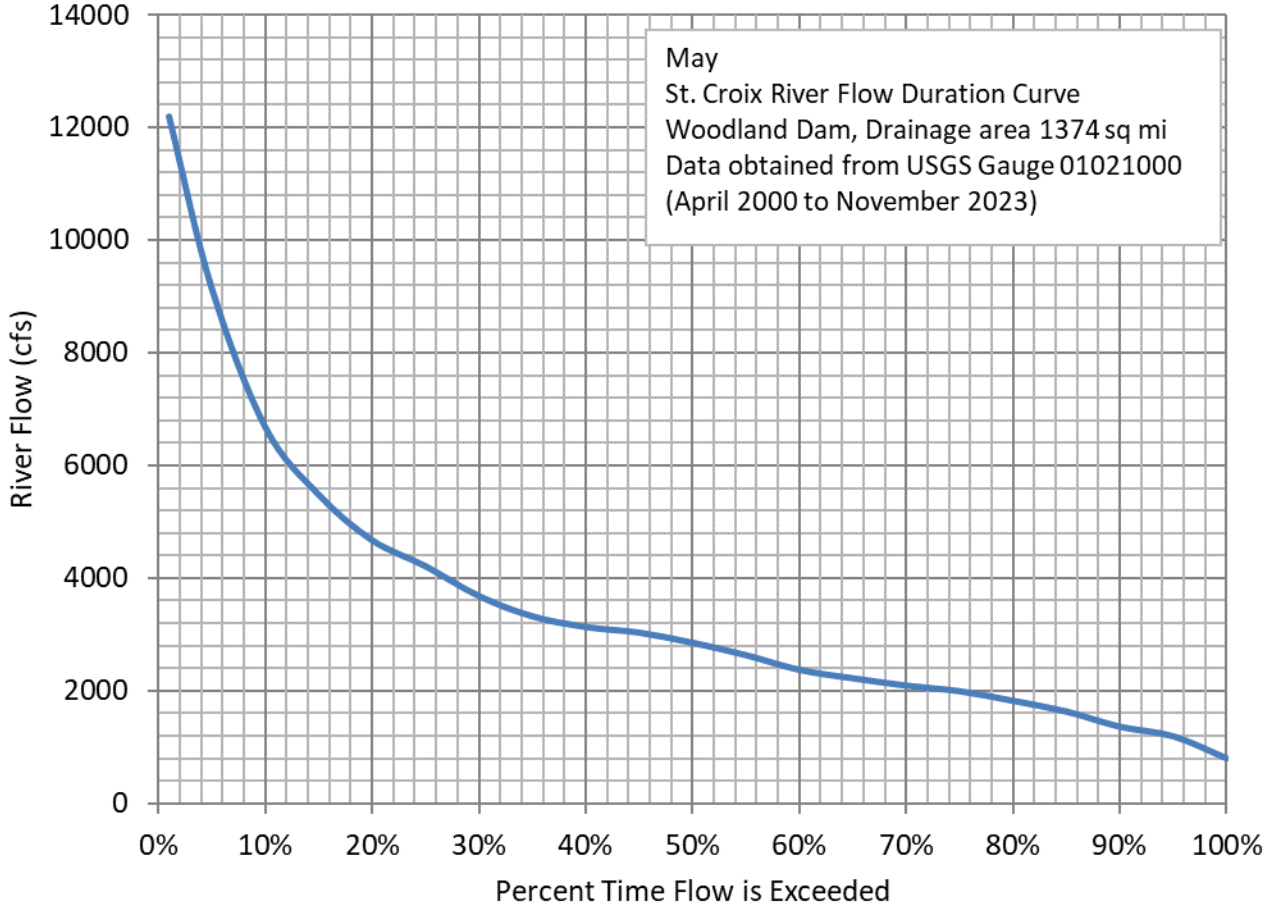
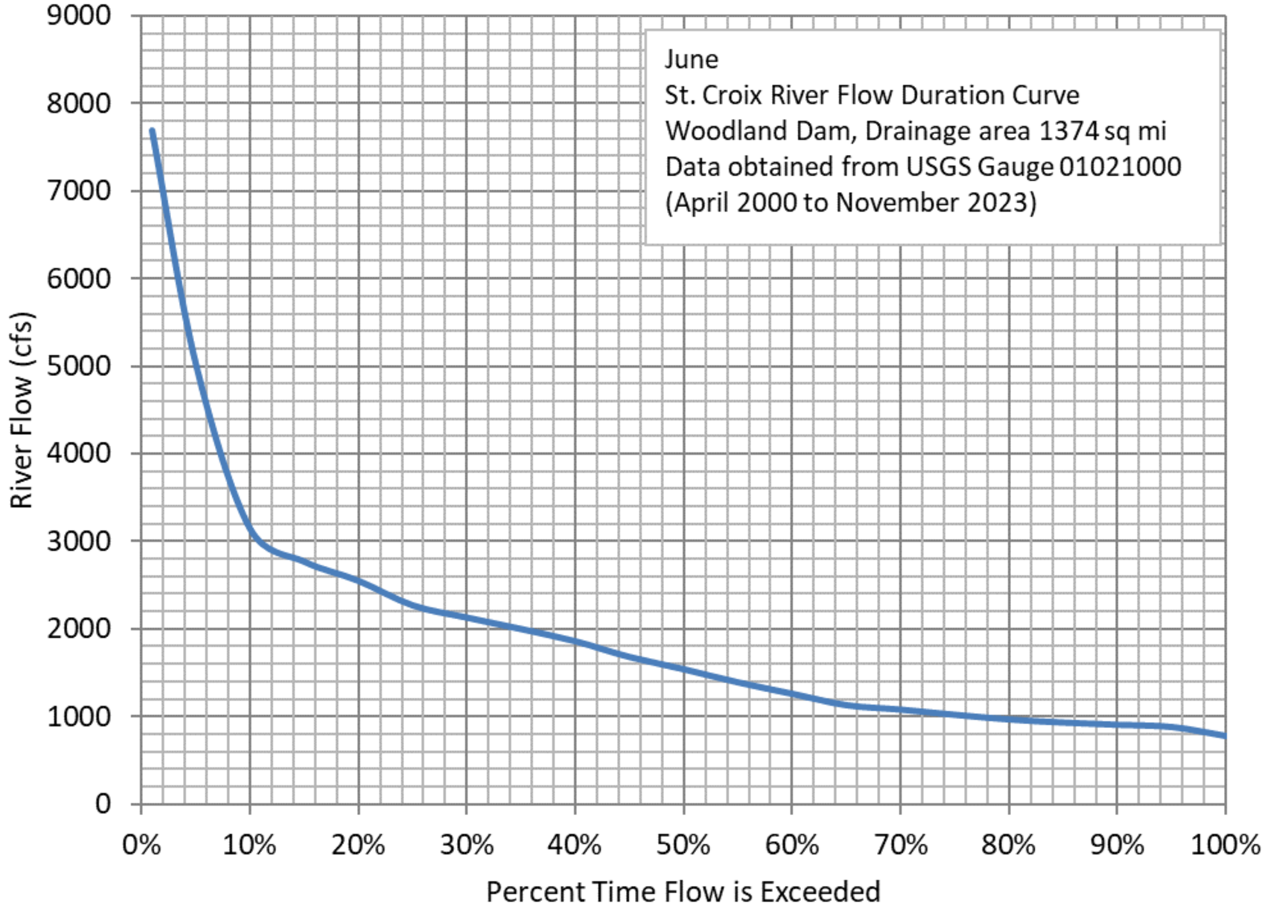
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded



April
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
16000
14000
12000
10000
8000
6000
4000
2000
0
River Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


May
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
Percent Time Flow is Exceeded
14000
12000
10000
8000
6000
4000
2000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


June
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
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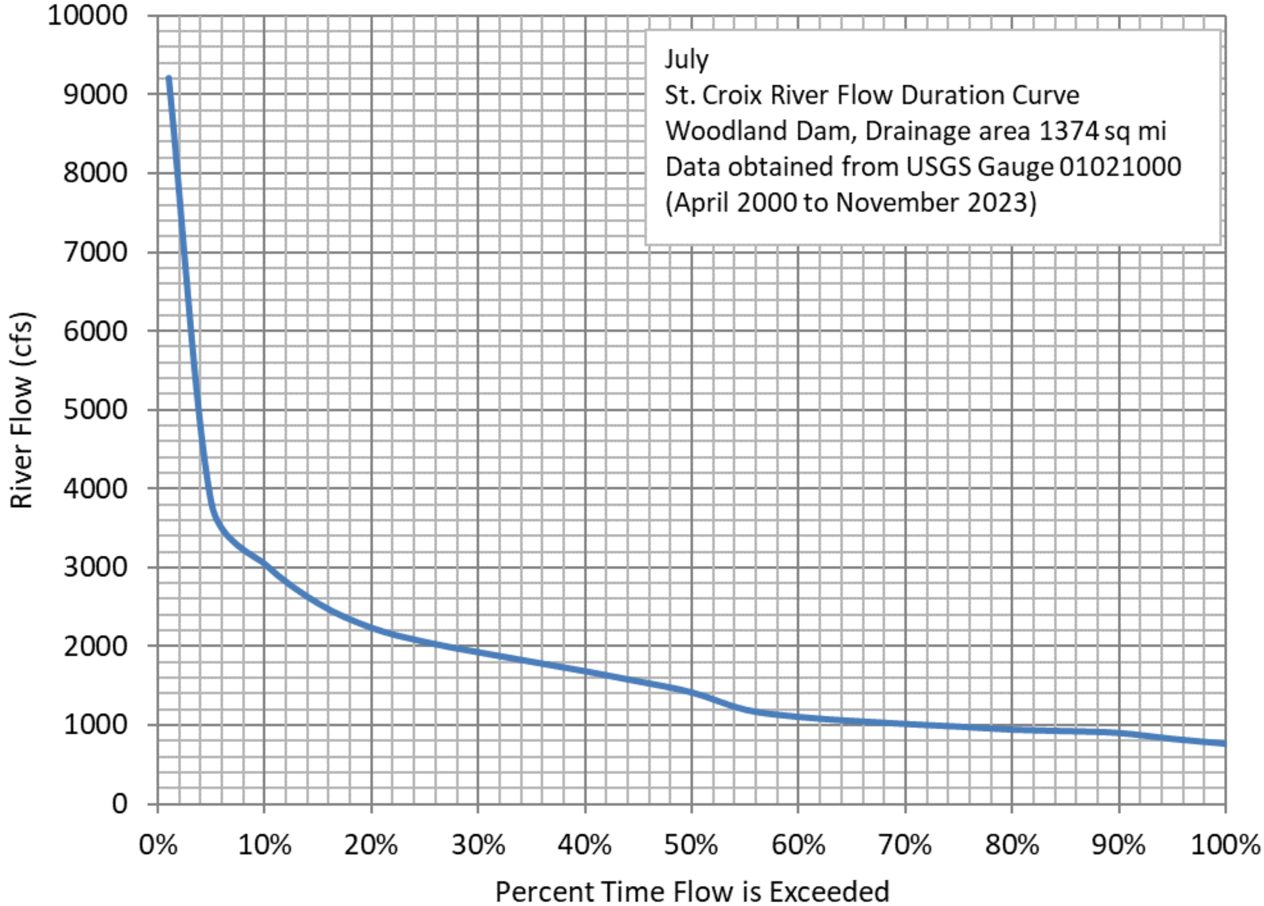
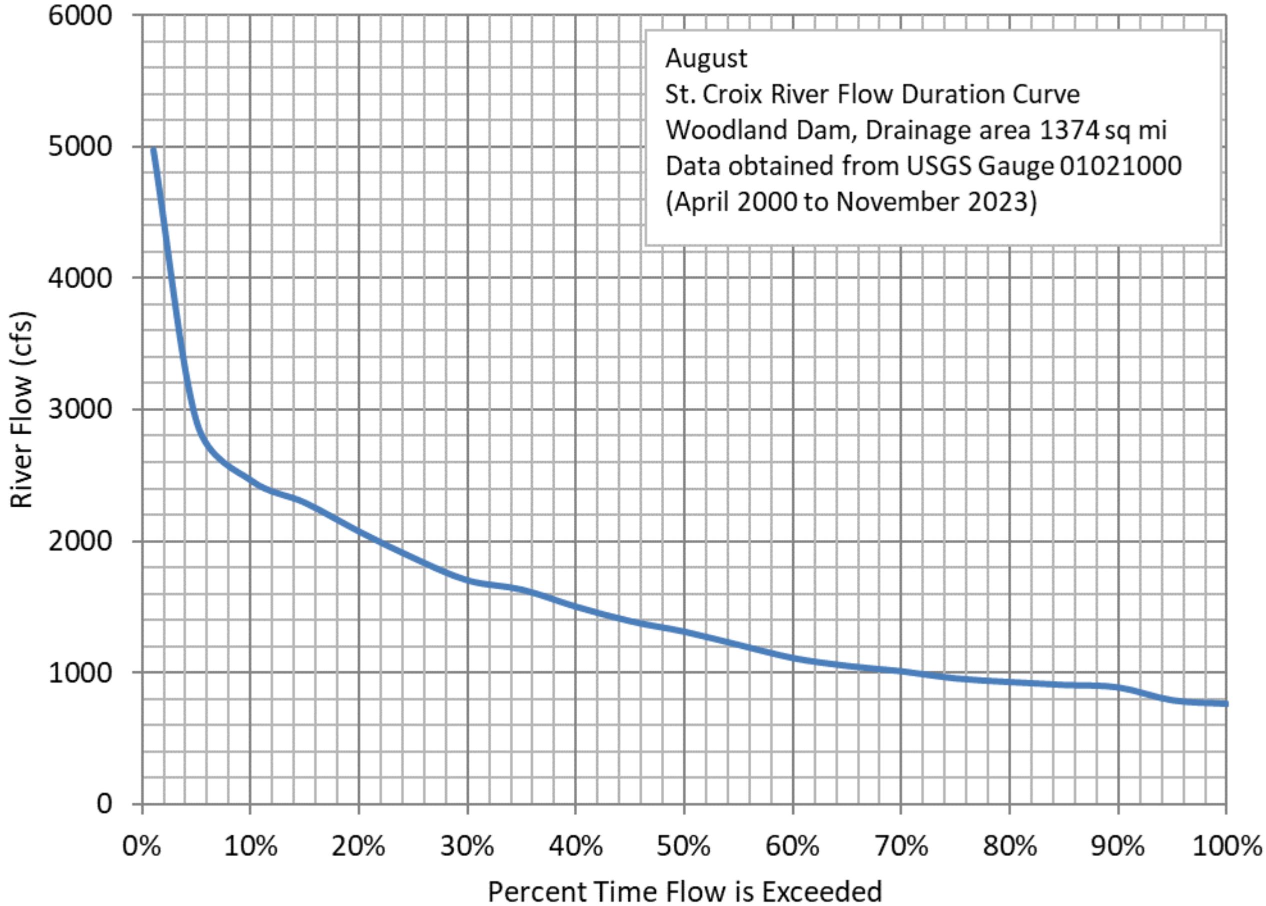
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


July
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


August
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
6000
5000
4000
3000
2000
1000
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20%
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40%
50%
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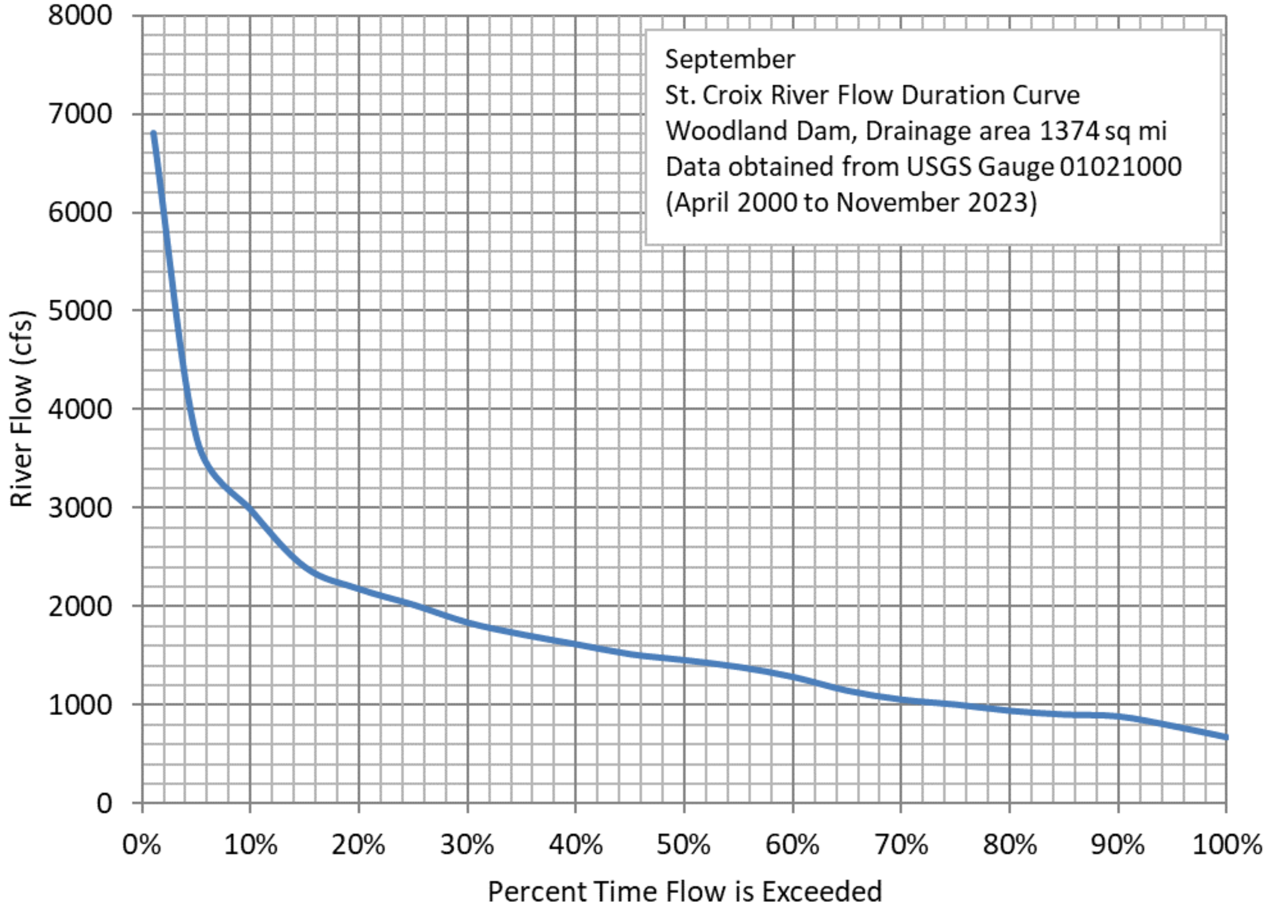
70%
80%
90%
100%
Percent Time Flow is Exceeded


September
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
8000
7000
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5000
4000
3000
2000
1000
0
River Flow (cfs)
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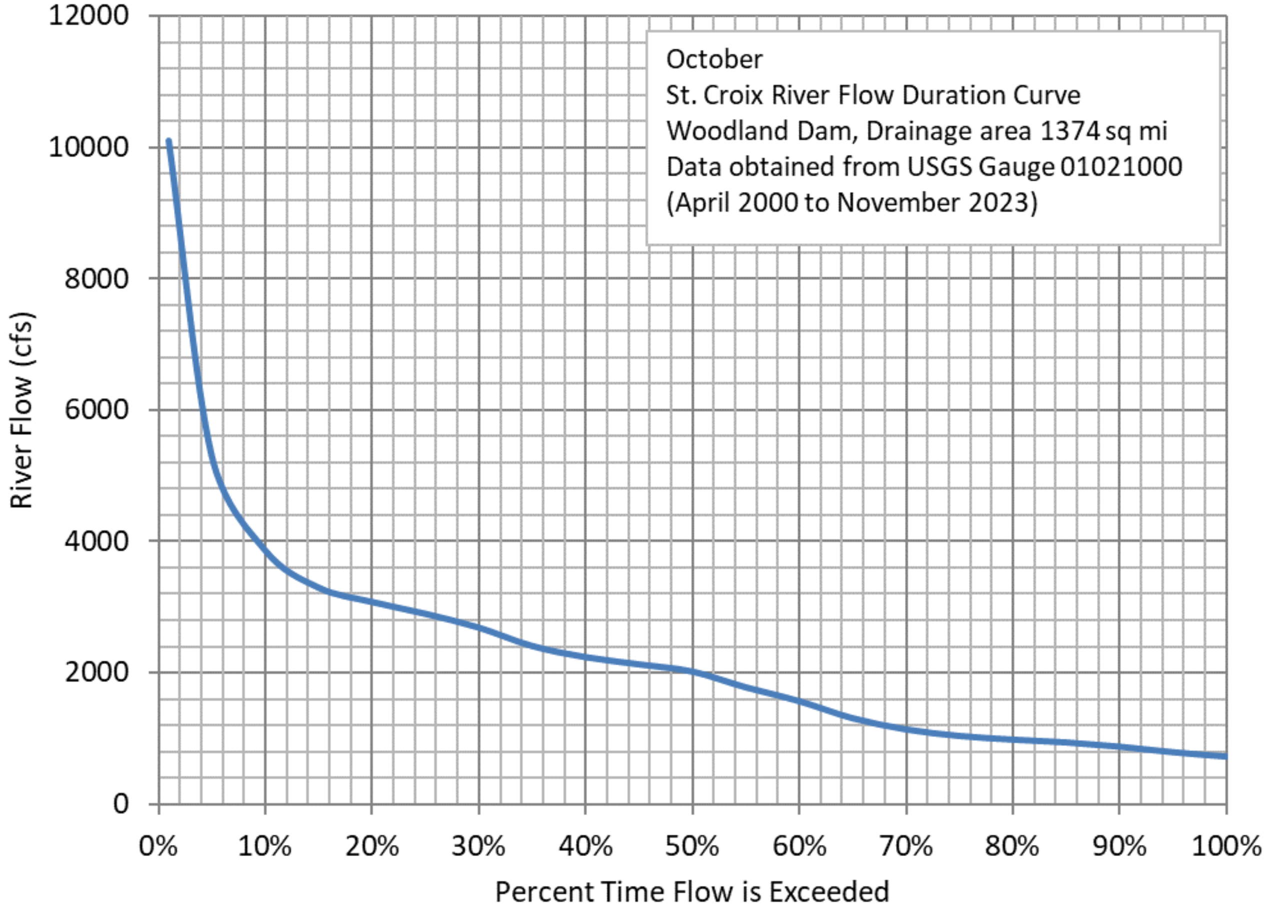
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


October
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
12000
10000
8000
6000
4000
2000
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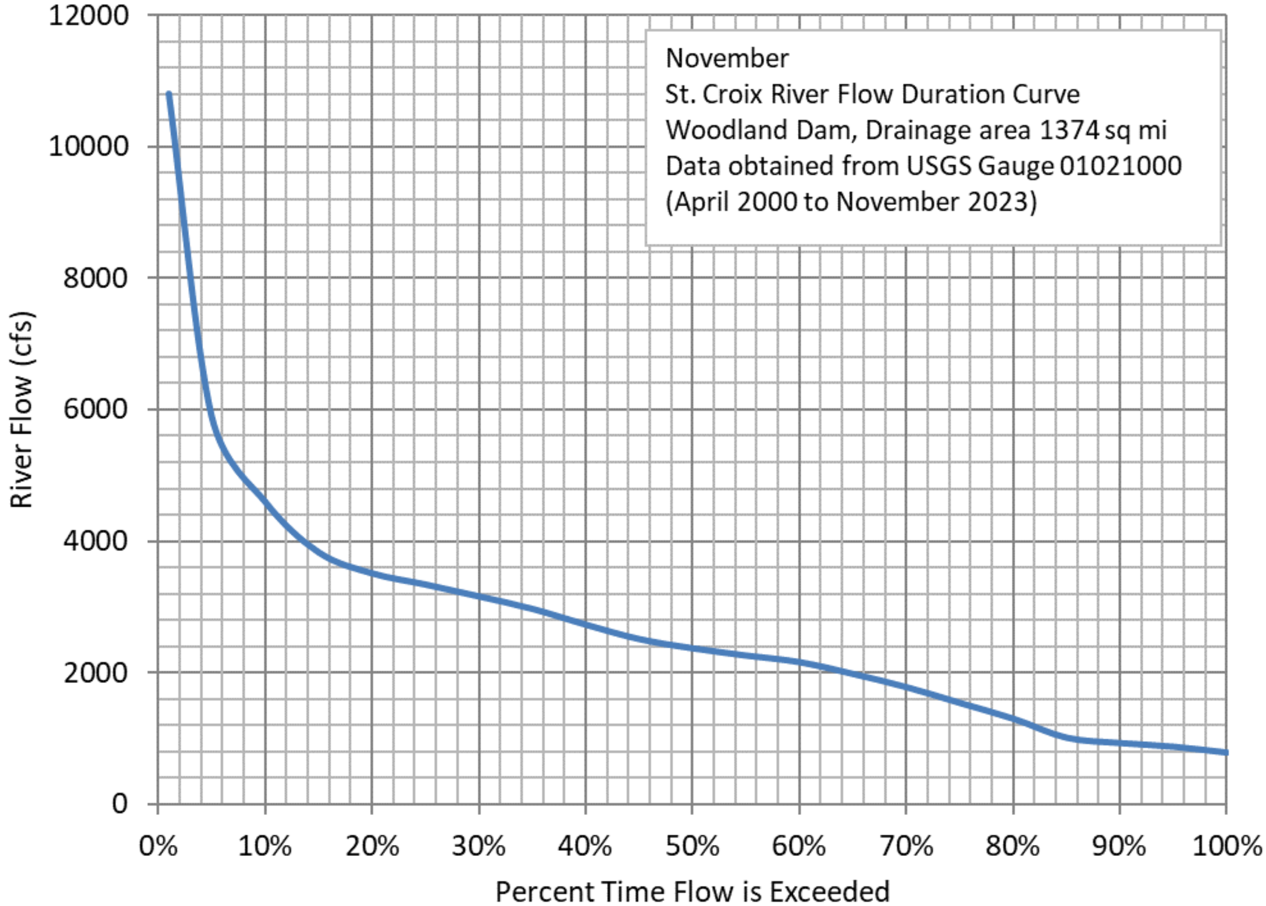
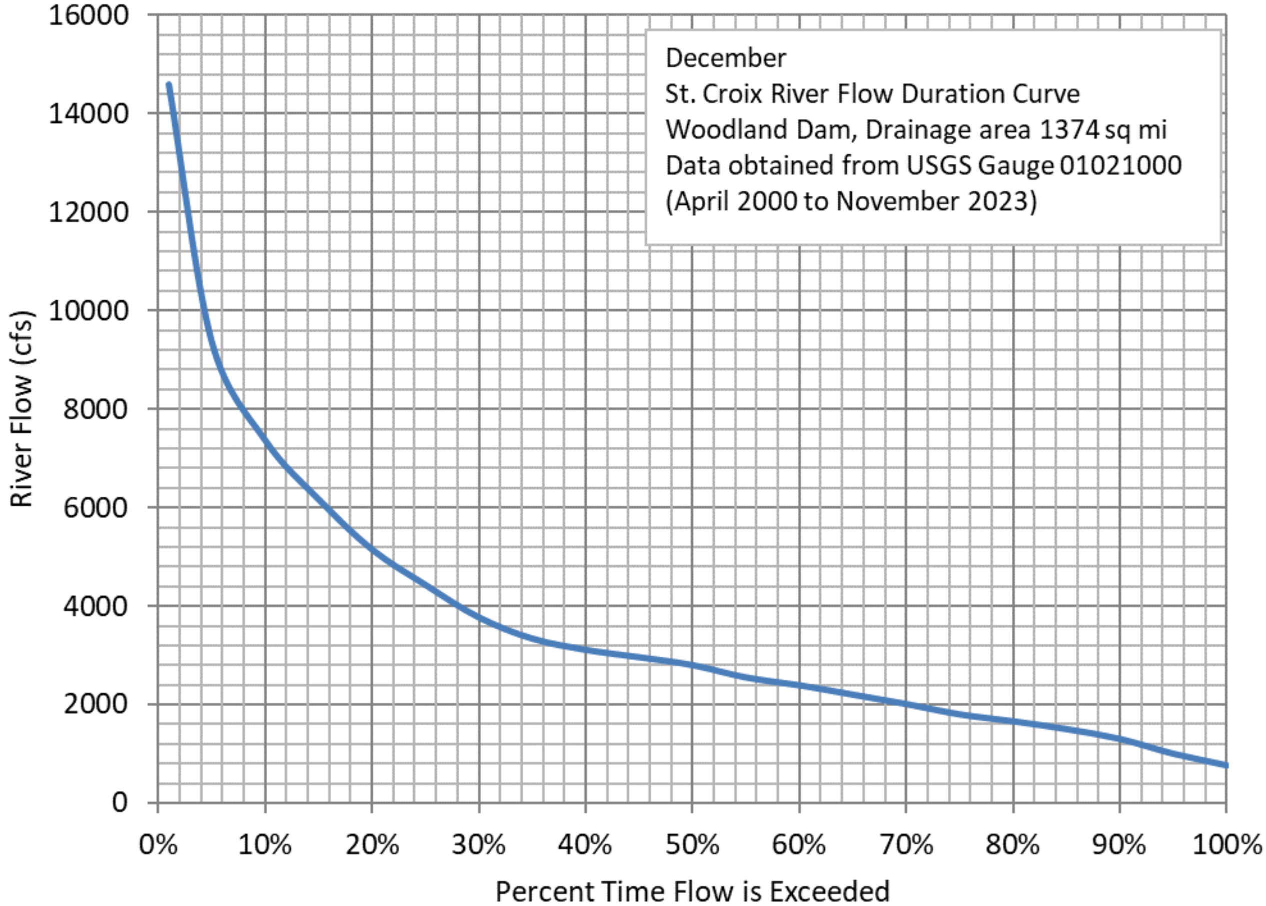
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


November
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
0
2000
4000
6000
8000
10000
12000
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded


December
St. Croix River Flow Duration Curve
Woodland Dam, Drainage area 1374 sq mi
Data obtained from USGS Gauge 01021000
(April 2000 to November 2023)
River Flow (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Time Flow is Exceeded

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SECTION 31 37 00

RIPRAP

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section describes the materials and installation of riprap and riprap bedding as shown on the Contract Drawings.

1.02. SUBMITTALS

A. Submit letter identifying source of stone and current analysis of stone gradation.

B. Submit current analysis from an independent laboratory showing rock quality test results.

C. Submit laboratory test report and material certifications verifying that the materials intended for use on the project conform to the requirements specified in this Section.

1.03. REFERENCE STANDARDS

A. Maine Department of Transportation (MDOT), Standard Specifications, latest edition.

1.04. TESTS

A. Perform laboratory testing of imported riprap materials.

PART 2 - MATERIALS

2.01. RIPRAP

A. Riprap shall be sound, angular and durable rock meeting the requirements of Section 703.28 Heavy Riprap of the MDOT Standard Specifications.

B. Rounded stone or boulders will not be acceptable as riprap material.

C. Each piece shall have its greatest dimension not greater than three times its least dimension.

D. Riprap shall be 18-inch nominal size (d_{50}) as shown in the Drawings, and shall have the following gradations:

Table 1: Riprap Nominal Stone Size (d_{50})		
Percent of Material Smaller than Typical Stone Size	18-inch Riprap	
	Typical Stone Dimension (inches)[1]	Typical Stone Weight (Pounds)[2]
70 – 100	30	1280
50 – 70	24	650
35 – 50	18	275
2 – 10	6	10

[1] Equivalent spherical diameter based on a specific gravity of 2.5.

[2] Based on typical rock mass.

2.02. BEDDING FOR RIPRAP

A. Riprap bedding shall be free-draining, sound and durable crushed rock meeting the Gravel Barrow material requirements of MDOT Standard Specifications, Section 703.20.

B. Riprap bedding material shall have the following gradation:

Table 2: Riprap Bedding – MDOT Gravel Barrow Material	
Sieve Size	Percent (%) Passing
3”	100
1/4”	0 – 70
No. 200	0 – 10

PART 3 - EXECUTION

3.01. SUBGRADE PREPARATION

A. Prepare subgrade in accordance with Section 31 23 01 Earthwork and Rock Excavation.

3.02. RIPRAP AND RIPRAP BEDDING PLACEMENT

A. Place riprap and riprap bedding at the locations and to the thicknesses, lines, and grades shown on the Drawings.

B. Compaction of riprap bedding will not be required; however, riprap bedding shall be spread in such a manner as to form a smooth, uniform layer under the riprap.

C. Riprap shall be placed with smaller rock fragments used to fill in the voids between larger rock fragments in such a manner as to form a smooth, uniform, well graded layer of riprap that is stable and not susceptible to sliding.

D. Riprap shall also be placed to form smooth transitions to embankment slopes, channel slopes, and channel side slopes.

E. No distinct horizontal, vertical, or angular joints will be allowed in the riprap that would reduce interlocking capability of the riprap.

END OF SECTION

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SECTION 31 63 33

MICROPILES

PART 1 - GENERAL

1.01. DESCRIPTION

A. This work shall consist of providing, installing and constructing micropiles as shown on the Contract Drawings and approved working drawings and as specified herein. The micropile specialty Contractor is responsible for furnishing of all materials, products, accessories, tools, equipment, services, transportation, handling, labor and supervision, manufacturing techniques installation, and testing for micropiles and pile top attachments required for the Project.

B. The selected micropile Contractor shall provide all complete installation activities for the micropile foundation systems that will develop the load capacities indicated on the contract plans. The micropile load capacities shall be verified by verification load testing and proof load testing as required and must meet the test acceptance criteria specified herein.

1.02. REFERENCES

The following publications form a part of this specification to the extent indicated by the references. Where reference is made to one of the following standards, the revision in effect at the time of bid opening shall apply. Omission or changes in titles of a code or standard does not relieve the Contractor of the requirement to complete all work in accordance with industry-standard codes, specifications, or law.

A. American Association of State Highway and Transportation Officials (AASHTO):

1. M31: Standard Specification for Deformed and Plain Carbon and Low-Alloy Steel Bars for Concrete Reinforcement.

2. M45: Standard Specification for Aggregate for Masonry Mortar.

3. M183: Standard Specification for Structural Steel.

4. M194: Standard Specification for Chemical Admixtures for Concrete.

5. M223: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality.

6. M275: Standard Specification for High-Strength Steel Bars for Prestressed Concrete.

7. T26: Standard Test Method of Water to Be Used Concrete.

8. T106: Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens).

9. T133: Standard Method of Test for Density of Hydraulic Cement.

B. American Society for Testing and Materials (ASTM):

1. A36: Standard Specification for Carbon Structural Steel.

2. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

3. A252: Welded and Seamless Steel Pipe Piles.

4. A572: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

5. A615: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

6. A722: Standard Specification for High-Strength Steel Bars for Prestressed Concrete.

7. A775: Standard Specification for Epoxy-Coated Steel Reinforcing Bars.

8. A934: Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.

9. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).

10. C144: Standard Specification for Aggregate for Masonry Mortar.

11. C188: Standard Test Method for Density of Hydraulic Cement.

12. C494: Standard Specification for Chemical Admixtures for Concrete.

13. C595: Standard Specification for Blended Hydraulic Cements.

14. D1143: Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load.

15. D1784: Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

16. D3689: Standard Test Methods for Deep Foundation Elements Under Static Axial Tensile Load.

17. D3966: Standard Test Methods for Deep Foundations Under Lateral Load.

C. American Welding Society (AWS)

1. D1.1 Structural Welding Code – Steel.

D. American Petroleum Institute (API).

1. 5CT (N-80) Specification for casing and tubing.

2. RP 13B-1 Recommended Practice – Standard Procedure for Field Testing Water Based Drilling Fluids.

E. Refer to Division 03 Concrete specifications for concrete items and procedures not addressed in this specification.

1.03. AVAILABLE INFORMATION

Available information developed by the Engineer for the Project includes the following items:

A. Contract Drawings prepared by Alden/Verdantas.

B. Geotechnical Engineering Report prepared by Verdantas, dated December 20, 2024.

1.04. CONSTRUCTION SITE SURVEY

A. Before bidding the Work, the Contractor shall review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, and location of existing structures and above ground facilities.

B. The Contractor is responsible for field locating and verifying the location of all utilities shown on the plans prior to starting the Work. Coordinate with Woodland Pulp and maintain uninterrupted service for those utilities designated to remain in service throughout the Work. Notify the Engineer of any utility locations different from shown on the plans that may require micropile relocations or structure design modification. Subject to the Engineer's approval, additional cost to the Contractor due to micropile relocations and/or structure design modification resulting from utility locations different from shown on the plans, will be paid as Extra Work. The Contractor shall be responsible for identifying special shielding and/or setbacks required related to above ground electrical lines and coordinating shielding or temporary disconnects with Woodland Pulp.

C. Prior to the start of any micropile construction activity, the Contractor, Woodland Pulp, and the Engineer shall jointly inspect the site to observe and document the pre-construction condition of the site, existing structures and facilities.

1.05. SUBMITTALS

A. Qualifications

1. The micropile Contractor shall be experienced in the construction and load testing of micropiles and have successfully constructed at least 5 projects in the last 5 years involving construction totaling at least 100 micropiles of similar capacity to those required in these plans and specifications.

2. The Contractor shall have previous micropile drilling and grouting experience in soil/rock similar to project conditions. The Contractor shall submit construction details, structural details and load test results for at least three previous successful micropile load tests from different projects of similar scope to this project.

3. The Contractor shall assign the Contractor’s Engineer to supervise its Work that has experience on at least 3 projects of similar scope to this project completed over the past 5 years. The Contractor shall be responsible for providing a micropile installation crew that has sufficient experience and skills to successfully, safely, and efficient complete the Work required. The on-site foremen and drill rig operators shall have experience on at least 3 projects over the past 5 years installing micropiles of equal or greater capacity than required in these plans and specifications, and at least 3 projects where the micropiles were installed into bedrock.

4. At least 45 calendar days before the planned start of micropile construction, the Contractor shall submit the completed project reference list and a personnel list. The project reference list shall include a brief project description and the name and current phone number of the owners of those projects and load test reports. The Contractor’s personnel list shall identify the supervising project Contractor’s Engineer, drill rig operators, and on-site foremen to be assigned to the project. The personnel list shall contain a summary of each individual's experience and demonstrate that each individual is suitably qualified to facilitate the micropile Work. The Engineer will approve or reject the Contractor's qualifications within 15 calendar days after receipt of a complete submission.

5. Additional time required due to incomplete or unacceptable submittals will not be cause for time extension or impact or delay claims. All costs associated with incomplete or unacceptable submittals shall be borne by the Contractor.

6. Work shall not be started, nor materials ordered, until the Engineer’s and Maine DMR’s written approval of the Contractor's experience qualifications is given.

Maine DMR may suspend the Work if the Contractor uses personnel not previously included in the list of qualified provided by the Contractor. If work is suspended, the Contractor shall be fully liable for all resulting costs and no adjustment in contract time will result from the suspension.

B. The Contractor shall prepare and submit to the Engineer, for review of completeness, the following for the micropile system or systems to be constructed:

1. Detailed step-by-step description of the proposed micropile construction procedure, including personnel and their specific roles, safety practices, material handling locations and sequencing, testing and equipment to assure quality control, and contingency planning. This step-by-step procedure shall be shown on marked-up versions of the design drawings in sufficient detail to allow the Engineer to monitor the construction and quality of the micropiles.

2. Proposed start date and micropile installation schedule providing the following:

   a. Micropile number

   b. Micropile design load

   c. Type and size of reinforcing steel

   d. Minimum bond length

   e. Total micropile length

   f. Micropile top footing attachment

3. If welding of casing is proposed, submit the proposed welding procedure and details of weld locations, certified by a qualified welding specialist.

4. Information on headroom and space requirements for installation equipment that verify the proposed equipment can effectively and safely perform at the site.

5. Plan describing how surface water, drill flush, and excess waste grout will be controlled and properly disposed.

6. Certified mill test reports for the reinforcing steel or coupon test results for permanent casing without mill certification. The ultimate strength, yield strength, elongation, and material properties composition shall be included. For API N-80 pipe casing, coupon test results may be submitted in lieu of mill certification.

7. Proposed Grouting Plan. The grouting plan shall include complete descriptions, details, and supporting calculations for the following:

a. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports.

b. Methods and equipment for accurately placing, monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed.

c. Contingency plan for unexpected grout loss and/or grout breakout.

d. Grouting rate calculations, when requested by the Engineer. The calculations shall be based on the initial pump pressures or static head on the grout and losses throughout the placing system, including anticipated head of drilling fluid (if applicable) to be displaced.

e. Estimated curing time for grout to achieve specified strength. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification and acceptance and start of production work. During production, grout shall be tested in accordance with Section 3.04.E.

f. Procedure and equipment for Contractor monitoring of grout quality.

8. Detailed plans for the proposed micropile load testing method. This shall include all drawings, details, and structural design calculations necessary to clearly describe the proposed test method, reaction load system capacity and equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements in accordance with Section 3.06, Pile Load Tests.

9. Calibration reports and data for each test jack, pressure gauge and master pressure gauge and electronic load cell to be used. The calibration tests shall have been performed by an independent testing laboratory, and tests shall have been performed within 90 calendar days of the date submitted. Testing shall not commence until the Engineer has reviewed and accepted the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

Work other than test pile installation shall not begin until the construction submittals have been received, reviewed, and accepted in writing by the Engineer. Provide submittal items 1 through 5 at least 21 calendar days prior to initiating micropile construction, item 7 as the work progresses for each delivery and submittal items 6, 8 and 9 at least 7 days prior to start of micropile load testing or incorporation of the respective materials into the work. The Contractor shall allow the Engineer 7 calendar days to review the construction submittals after a complete set has been received. Additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact claims by the Contractor. All costs associated with incomplete or unacceptable Contractor submittals shall be the responsibility of the Contractor.

1.06. QUALITY ASSURANCE

A. All micropile installation work shall be inspected by the Engineer during installation and approval by the Engineer will be required prior to construction of the pile cap(s).

1.07. PRE-CONSTRUCTION MEETING

A. A pre-construction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Engineer, prime Contractor, micropile installation specialty Contractor, excavation Contractor, and Contractor’s Engineer shall attend the meeting. Attendance is mandatory.

B. The pre-construction meeting will be conducted to clarify the construction requirements for the Work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineation of responsibilities amongst the prime Contractor and its various Subcontractors, specifically those pertaining to excavation for micropile structures, addressing anticipated subsurface conditions, micropile installation and testing, micropile structure survey control and site drainage control.

PART 2 - MATERIALS

2.01. GENERAL

A. Furnish materials new and without defects. Transport, handle, store, and use materials in a manner that fully preserves their intended characteristics and function. Remove defective materials from the jobsite at no additional cost.

2.02. ADMIXTURES FOR GROUT

A. Admixtures shall conform to the requirements of ASTM C494/AASHTO M194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of the Engineer. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer’s recommendations. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations and anchorage covers. Accelerators are not permitted. Admixtures containing chlorides are not permitted.

2.03. CEMENT

A. All cement shall be Portland Cement, ASTM C595, Type IL.

2.04. CENTRALIZERS AND SPACERS

A. Centralizers and spacers shall be fabricated from: schedule 40 PVC pipe or tube; steel, or other material non-detrimental to the reinforcing steel. Centralizers shall be inert with regard to any reaction with grout and/or concrete. Wood shall not be used.

2.05. EPOXY COATING

A. Where specified, the minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.3 mm. Epoxy coating shall be in accordance with ASTM A775 or ASTM A934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated.

2.06. FINE AGGREGATE

A. If sand - cement grout is used, sand shall conform to ASTM C144/AASHTO M45.

2.07. GALVANIZATION

A. If used, galvanization shall meet the requirements of ASTM A153.

2.08. GROUT

A. Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 2,000 psi and a 28-day compressive strength of 4,000 psi per AASHTO T106/ASTM C109.

2.09. PERMANENT CASING PIPE

A. Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness shown on the approved Working Drawings. The permanent steel casing/pipe:

   1. Shall meet the Tensile Requirements of API 5CT (N80), except the yield strength shall be a minimum of 80,000 psi to 11,0000 psi as used in the design submittal.

   2. May be new "Structural Grade" (a.k.a. "Mill Secondary") steel pipe meeting above but without Mill Certification, free from defects (dents, cracks, tears) and with two coupon tests per truckload delivered to the fabricator.

B. For permanent casing/pipe that will be welded for structural purposes, the following material conditions apply:

   1. the carbon equivalency (CE) as defined in AWS D1.1, Section XI5.1, shall not exceed 0.45, as demonstrated by mill certifications;

   2. the sulfur content shall not exceed 0.05%, as demonstrated by mill certifications.

C. For permanent casing/pipe that will be shop or field welded, the following fabrication or construction conditions apply:

1. the steel pipe shall not be joined by welded lap splicing;

2. welded seams and splices shall be complete penetration welds;

3. partial penetration welds may be restored in conformance with AWS D1.1;

4. the proposed welding procedure certified by a welding specialist shall be submitted for approval.

D. Threaded casing joints are not permitted on this Project.

2.10. PLATES AND SHAPES

A. Structural steel plates and shapes for pile top attachments shall conform to ASTM A36/AASHTO M183, or ASTM A572/AASHTO M223.

2.11. REINFORCING BARS

A. Reinforcing steel shall be deformed bars in accordance with ASTM A615/AASHTO M31, Grade 75 or ASTM A722/AASHTO M275, Grade 150.

B. When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, the threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or may be machine cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the Plans shall be provided, at no additional cost.

C. Bar tendon couplers, if required, shall develop the same ultimate tensile strength of the bars without evidence of any failure.

2.12. SHEATHING

A. Smooth plastic sheathing, including joints, shall be watertight. Polyvinyl chloride (PVC) sheathing shall conform to ASTM D1784, Class 13464-B.

2.13. WATER

A. Water used in the grout mix shall conform to AASHTO T26 and shall be potable, clean, and free from substances that may be injurious to cement and steel.

PART 3 - EXECUTION

3.01. SITE DRAINAGE CONTROLS

A. The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accordance with the standard specifications and all applicable local codes and regulations.

B. Provide positive control and discharge of all surface water that could adversely affect construction of the micropile installation. Maintain all features, pipes and/or conduits used to control surface water during construction.

C. Repair damage caused by surface water at no additional cost.

D. Upon substantial completion of the Work, remove surface water control features, pipes or conduits from the site. Alternatively, with the approval of Woodland Pulp and the Engineer, pipes or conduits that are left in place may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

E. Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation or drilling. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Cost of remedial measures or repair work resulting from encountering unanticipated subsurface drainage structures, will be paid for as Extra Work provided they were approved in advance by the Engineer and Maine DMR.

3.02. EXCAVATION

A. Coordinate the work and the excavation so the micropile structures are safely constructed. Confer with Woodland Pulp and the Engineer in advance with regard to any excavations that have the potential to undermine existing active structures.

B. Perform the micropile construction preparation and related excavation in accordance with the Plans and approved submittals. No excavations steeper than those specified herein or shown on the Plans will be made above or below the micropile structure locations without written approval of the Engineer.

C. Properly manage all excavated material to prevent stormwater impacts and interference with the Work.

D. If any underpinning or other stabilization of existing foundations or structures is required, notify the Engineer to discuss an approach and implement the approved approach as paid for Extra Work.

3.03. MICROPILE ALLOWABLE CONSTRUCTION TOLERANCES

A. Centerline of piling shall not be more than 3 inches from indicated plan location.

B. Pile shall be plumb within 2 percent of total-length plan alignment.

C. Top elevation of pile shall be plus 1 inch or minus 2 inches maximum from vertical elevation indicated.

D. Centerline of reinforcing steel shall not be more than 0.75 inch from indicated location.

3.04. MICROPILE INSTALLATION

The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure(s) used for the installation of the micropiles. The micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

A. Drilling:

1. The drilling equipment and methods shall be suitable for efficient and safe drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services.

2. Temporary casing or other approved method of pile drillhole support will be required in caving or unstable ground to permit the pile shaft to be formed to the minimum design drillhole diameter and length. The Contractor’s proposed method(s) to provide drillhole support and to prevent detrimental ground movements shall be reviewed by the Engineer. Detrimental ground movement is defined as movement which requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

3. Costs of removal or remedial measures due to encountering unanticipated subsurface obstructions will be paid for as Extra Work provided they are approved in advance by the Engineer and Maine DMR.

B. Pipe Casing and Reinforcing Bars Placement and Splicing:

1. Reinforcement may be placed either prior to grouting or placed into the grout-filled drillhole before temporary casing (if used) is withdrawn. Reinforcement surfaces shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

2. The Contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations.

3. Centralizers and spacers (if used) shall be provided at 10 feet maximum spacing along the reinforcement. The upper and lower most centralizer shall be located a maximum of 5 feet from the top and bottom of the micropile. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. The central reinforcement bars with centralizers shall be lowered into the stabilized drillhole and set. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. Contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion.

4. Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Splices and threaded joints shall meet the requirements of Materials Section 2.0. Threaded pipe casing joints will not be permitted. When multiple bars are used, bar splices shall be staggered at least 1 foot.

C. Grouting:

1. Micropiles shall be primary grouted the same day the load transfer bond length is drilled. The Contractor shall use a stable neat cement grout or a sand cement grout with a minimum 28- day unconfined compressive strength of 4,000 psi.

2. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations.

3. The grouting equipment used shall produce a grout free of lumps and undispersed cement.

4. The Contractor shall have means and methods of measuring the grout quantity and pumping pressure during the grouting operations. The grout pump shall be equipped with a pressure gauge to monitor grout pressures. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauges shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater.

5. The grout shall be kept in agitation prior to mixing. Grout shall be placed within one hour of mixing. The grouting batch and equipment shall be sized to enable each pile to be grouted in one continuous operation.

6. The grout shall be injected from the lowest point of the drill hole and injection shall continue until uncontaminated grout flows from the top of the pile. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods.

Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed the grout level is brought back up to the design level before the next length is removed. The tremie pipe or casing shall always extend below the level of the existing grout in the drillhole.

7. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations.

8. Grout within the micropiles shall be allowed to attain the required design strength prior to being loaded.

9. If the Contractor elects to use a post-grouting system, Working Drawings and details shall be submitted to the Engineer for review in accordance with Section 1.05, Pre-installation Submittals.

D. Ground Heave or Subsidence:

1. During construction, the Contractor shall observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave, lateral displacement, or subsidence.

2. Immediately notify the Engineer if signs of movements are observed.

3. The Contractor shall immediately suspend or modify drilling or grouting operations if ground heave, lateral displacement or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged, or have the potential to be damaged, from the drilling or grouting.

4. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs.

5. When due to the Contractor’s methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer and Maine DMR, the costs of providing corrective actions will be borne by the Contractor. When due to differing site conditions, as determined by the Engineer and Maine DMR, the costs of providing corrective actions will be paid as Extra Work.

E. Grout Testing:

1. Grout within the micropile verification and proof test piles shall attain the minimum required 3-day compressive strength of 2,000 psi prior to load testing.

2. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive

strengths for installation of pre-production verification test piles and initial production piles.

3. During production, micropile grout shall be tested by the Contractor for compressive strength in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one set of three 2 inch grout cubes from each grout plant each day of operation or per every 10 piles, whichever occurs more frequently. The compressive strength shall be the average of the 3 cubes tested.

4. Grout consistency as measured by grout density shall be determined by the Contractor per ASTM C188/AASHTO T133 or API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat cement grout. The measured grout density shall be between 1,700 kg/m3 and 1,900 kg/m3.

5. Grout samples shall be taken directly from the grout plant. Provide grout cube compressive strength and grout density test results to the Engineer within 24 hours of testing.

3.05. MICROPILE INSTALLATION RECORDS

A. Contractor shall prepare and submit to the Engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on the micropile installation log. A separate log shall be provided for each micropile.

3.06. PILE LOAD TESTS

A. Perform verification and proof testing of piles at the locations specified herein or designated by the Engineer. Perform compression load testing in accord with ASTM D1143, tension load testing in accord with ASTM D3689, and lateral load testing in accord with ASTM D3966, except as modified herein.

B. Verification Load Tests:

1. Perform pre-production verification pile load testing to verify the design of the pile system and the construction methods proposed prior to installing any production piles. Sacrificial verification test piles shall be constructed in conformance with the approved Working Drawings. Verification test pile(s) shall be installed at locations mutually agreed upon by all parties during the pre-construction site walk.

2. Verification load tests shall be performed to demonstrate that the Contractor installed micropiles will meet the required compression and tension load capacities and load test acceptance criteria and to verify that the length of the

micropile bond zone is adequate. The micropile verification load test results must verify the Contractor's design and installation methods, and be reviewed and accepted by the Engineer prior to beginning installation of production micropiles.

3. The drilling-and-grouting method, casing length and outside diameter, reinforcing bar lengths, and depth of embedment for the verification test pile(s) shall be identical to those specified for the production piles at the given locations. The verification test micropile structural steel sections shall be sized to safely resist the maximum test load.

4. The maximum verification and proof test loads applied to the micropile shall not exceed 80 percent of the structural capacity of the micropile structural elements, to include steel yield in tension, steel yield or buckling in compression, or grout crushing in compression. Any required increase in strength of the verification test pile elements above the strength required for the production piles shall be provided for in the Contractor’s bid price.

5. The jack shall be positioned at the beginning of the test such that unloading and repositioning during the test will not be required. When both compression and tension load testing is to be performed on the same pile, the pile shall be tested under compression loads prior to testing under tension loads.

C. Testing Equipment and Data Recording:

1. Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. All gauges used shall have up-to-date certifications of calibration. The load cell is required only for the creep test portion of the verification test. The Contractor shall provide a description of test setup and jack, pressure gauge and load cell calibration curves.

2. Design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur. Align the jack, bearing plates, and stressing anchorage such that unloading and repositioning of the equipment will not be required during the test.

3. Apply and measure the test load with a hydraulic jack and pressure gauge. The pressure gauge shall be graduated in 75 psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. Monitor the creep test load hold during verification tests with both the pressure gauge and the electronic load cell. Use the load cell to accurately maintain a constant load hold during the creep test load hold increment of the verification test.

4. Measure the pile top movement with a dial gauge capable of measuring to 0.025 mm. The dial gauge shall have a travel sufficient to allow the test to be done without having to reset the gauge. Visually align the gauge to be parallel with the axis of the micropile and support the gauge independently from the jack, pile or reaction frame. Use a minimum of two dial gauges when the test setup requires reaction against the ground or single reaction piles on each side of the test pile.

D. Verification Load Testing Schedule:

1. Test verification piles designated for compression or tension load testing to a maximum test load of 2.0 times the micropile Design Load shown on the Plans or Working Drawings. The verification pile load tests shall be made by incrementally loading the micropile in accordance with the following cyclic load schedule for both compression and tension loading:

E.

Step	Loading	Applied Load	Hold Time (min.)
1	Apply AL		2.5
2	Cycle 1	0.15 DL	2.5
		0.30 DL	2.5
		0.45 DL	2.5
		AL	1
3	Cycle 2	0.15 DL	1
		0.30 DL	1
		0.45 DL	2.5
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2,5
		1.00 DL	2.5
		AL	1
4	Cycle 3	0.15 DL	1
		1.00 DL	1
		1.15 DL	2.5
		1.30 DL	10 to 60 minutes
		1.45 DL	2.5
		AL	1
5	Cycle 4	0.15 DL	1
		1.45 DL	1
		1.60 DL	1
		1.75 DL	2.5
		1.90 DL	2.5
		2.00 DL	10
		1.50 DL	5
		1.00 DL	5
		0.50 DL	5
		AL	5

2. Pile top movement shall be measured at each load increment. The load-hold period shall start as soon as each test load increment is applied. The verification test pile shall be monitored for creep at the 1.30 Design Load (DL). Pile movement during the creep test shall be measured and recorded at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. The alignment load shall not exceed 5 percent of the DL load. Dial gauges shall be reset to zero after the initial AL is applied.

3. The acceptance criteria for micropile verification load tests are:

   a. The pile shall sustain the first compression or tension 1.0 DL test load with no more than 1 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

   b. At the end of the 1.30 DL creep test load increment, test piles shall have a creep rate not exceeding 1 mm/log cycle time (1 to 10 minutes) or 2 mm/log cycle time (6 to 60 minutes or the last log cycle if held longer). The creep rate shall be linear or decreasing throughout the creep load hold period.

   c. Failure does not occur at the 2.0 DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds 0.15 mm/kN.

4. The Engineer will provide the Contractor written confirmation of the micropile design and construction within 3 working days of the completion of the verification load tests. This written confirmation will either confirm the capacities and bond lengths specified in the Working Drawings for micropiles or reject the piles based upon the verification test results.

F. Verification Test Pile Rejection:

1. If a verification-tested micropile fails to meet the acceptance criteria, the Engineer may require modifying the installation methods, increasing the bond length, or changing the micropile type.

2. Any modifications of design or construction procedures or cost of additional verification test piles and load testing shall be at the Contractor’s expense. At the completion of verification testing, test piles shall be removed down to the elevation specified by the Engineer.

G. Proof Load Tests:

1. Perform proof load tests on the first set of production piles installed at each designated substructure unit prior to the installation of the remaining production piles in that unit. The first set of production piles is the number required to provide the required reaction capacity for the proof tested pile.

2. Proof testing shall be conducted at a frequency of 1 production pile per substructure unit or a minimum of 5% of installed piles. Location of additional proof test piles shall be as designated by the Engineer.

H. Proof Test Load Schedule:

1. Test piles designated for compression or tension proof load testing to a maximum test load of 1.60 times the micropile Design Load shown on the Plans or Working Drawings. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule, to be used for both compression and tension loading:

Step	Loading	Applied Load	Hold Time (min.)
1	Apply AL		2.5
2	Load Cycle	0.15 DL	2.5
		0.30 DL	2.5
		0.45 DL	2.5
		0.60 DL	2.5
		0.75 DL	2.5
		0.90 DL	2.5
		1.00 DL	2.5
		1.15 DL	2.5
		1.30 DL	10 to 60 minutes
		1.45 DL	2.5
		1.60 DL	2.5
3	Unload Cycle	1.30 DL	4
		1.00 DL	4
		0.75 DL	4
		0.50 DL	4
		0.25 DL	4
		AL	4

2. Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.30DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 1 mm, the Maximum Test Load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of DL. Dial gauges shall be reset to zero after the initial AL is applied.

3. The acceptance criteria for micropile proof load tests are:

    a. The pile shall sustain the compression or tension 1.0 DL test load with no more than 1 inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

    b. At the end of the 1.30DL creep test load increment, test piles shall have a creep rate not exceeding 1 mm/log cycle time (1 to 10 minutes) or 2 mm/log cycle time (6 to 60 minutes). The creep rate shall be linear or decreasing throughout the creep load hold period.

c. Failure does not occur at the 1.60DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds 0.15 mm/kN.

I. Proof Test Pile Rejection:

1. If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall immediately proof test another micropile within that footing.

2. For failed piles and further construction of other piles, the Contractor shall modify the design, the construction procedure, or both. These modifications may include installing replacement micropiles, incorporating piles at not more than 50% of the maximum load attained, postgrouting, modifying installation methods, increasing the bond length, or changing the micropile type.

3. Any modification that necessitates changes to the structure design shall require the Engineer's prior review and acceptance. Any modifications of design or construction procedures, or cost of additional verification test piles and verification and/or proof load testing, or replacement production micropiles, shall be at the Contractor's expense.

3.07. CLEANUP AND DEMOBILIZATION

A. Upon completion of micropile installation and acceptance of load test results by the Engineer, the Contractor shall remove and legally dispose of excess cuttings, slurry, and other excess materials off of Woodland Pulp's property.

B. The micropile specialty contractor, Contractor, and Woodland Pulp shall perform a final site walk to confirm the site has been properly cleaned-up prior to demobilization of the micropile specialty contractor.

END OF SECTION

SECTION 31 68 00

ROCK ANCHORS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section includes materials, fabrication, installation, and testing of the rock anchors (hollow core anchors) as indicated on the Drawings and described herein.

1.02 REFERENCES:

A. American Society for Testing and Materials (ASTM):

1. A36: Standard Specification for Carbon Structural Steel.

2. A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

3. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

4. A513: Standard Specifications for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing.

5. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-In. or 50-mm Cube Specimens).

6. E448: Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.

1.03 SUBMITTALS:

A. Submit shop drawings in accordance with Section 01 30 00.

B. Submit detailed installation drawings that indicate locations of fabricated items and details of installation procedures and equipment. Reproductions of contract documents will not be accepted for this purpose.

C. Submit fabricator and installer qualifications per Paragraph 1.04 below.

D. Submit the following data and test results:

1. Certified mill report for anchor rods with nuts and washers.

2. Certified mill report for bearing plate.

3. Grout mix design and grout mix test results.

4. Include catalogue cuts, technical data, and conformity to referenced ASTM standards.

E. Submit details showing the following information:

1. Hollow Injection bar.

2. Bearing assembly (bearing plate, washer, and nuts).

3. Total length of the anchor rod.

4. Anchor placement and installation instructions.

5. Grouting methods.

F. Submit driller logs and anchor records.

1.04 QUALITY ASSURANCE:

A. Submit anchor fabricator and installer qualifications as follows:

1. The submittals shall, where applicable, identify individuals who will be working on this contract and their relevant experience.

B. Fabricator Qualifications:

1. The anchors shall be fabricated by a manufacturer that has been in the practice of designing and fabricating hollow injection anchors similar in size and scope to this project for at least 5 years.

C. Installer Qualifications and Installation Plan:

1. Submit installation plan and installer qualifications and experience records. Experience records shall identify all the individuals responsible for the anchors and shall include a listing of projects of similar scope performed within the last 5 years along with points of contact.

1.05 ANCHOR INSTALLATION PREPARATORY MEETING:

A. Prior to commencing any work on the hollow bar anchors, the Contractor, including all field personnel to be involved in drilling and installation of the anchors, shall meet with the Engineer to review the Drawings and specifications, work plans, and submittals.

Drilling may commence upon approval of the anchor installation plan and procedures and after conducting the Preparatory Meeting.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. Materials shall be suitably wrapped, packaged or covered at the factory or shop to prevent being affected by dirt, water, oil, grease, and rust. Protect materials against abrasion or damage during shipment and handling.

B. Place materials stored at the site above ground on a well-supported platform and covered with plastic or other approved material. Materials shall be protected from adjacent construction operations.

C. Reject and remove from the site an anchor which is damaged by abrasion, cuts, nicks, heavy corrosion, pitting, welds or weld spatter.

D. Store structural material, either plain or fabricated, above ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter and protect from corrosion.

PART 2 - PRODUCTS

2.01 ANCHOR SYSTEM:

A. Each anchor system shall consist of the following assembly of components. Refer to the Drawings for the configuration of these components.

B. Anchor:

1. The anchor rod shall be a galvanized hollow injection bar with diameter as shown in the Drawings, Grade 85, conforming to ASTM A513.

    a. Minimum yield stress = 85 ksi (minimum)

    b. Ultimate stress = 105 ksi (minimum)

    c. Elongation = 15% (minimum)

2. Submit certified test reports for each heat or lot of anchor steel with materials delivered to the site. Submit mill reports and a certificate from the manufacturer stating chemical properties, ultimate strengths, yield strengths, modulus of elasticity, and any other physical properties needed for the required computations, for the type of steel furnished.

3. Manufacturer shall be Williams-Form Engineering or approved equivalent.

2.02 MANUFACTURED UNITS:

A. Bearing Plate Assembly:

1. The bearing plate assembly shall consist of steel bearing plate and nuts top and bottom. All components shall be galvanized steel.

2. The bearing plate shall be of the dimensions and thickness shown on the Drawings. The bearing plate shall conform to ASTM A36.

3. The nut shall be per the anchor manufacturer.

2.03 EQUIPMENT:

A. Drilling Equipment:

1. Provide drilling equipment suitable for advancing the drill tools to the depths and at the alignment required.

B. Grouting Equipment:

2. Grout Mixer:

   a. The grout mixer shall be a high-speed, high-shear, colloidal type grout mixer capable of continuous mechanical mixing that will produce uniform and thoroughly mixed grout which is free of lumps and undispersed cement.

   b. The mixer shall be equipped with a suitable water and admixture measuring device calibrated so that after each delivery the hands can be conveniently set back to zero.

3. Grout Pump:

   a. The grout pump shall be of the positive displacement type and shall be capable of pumping at all flow rates below 20 gpm, shall be capable of pumping at the pressure of at least 50 psi at zero flow rate.

   b. For neat cement grout, the pump shall have a screen with 0.125 inch maximum clearance to sieve the grout before being introduced into the pump. Screens are not required for shear type mixers. Make available a pump which is capable of pumping both neat cement grout mixes and sanded grout mixes.

c. The pumping equipment shall have a pressure gauge capable of measuring pressures of at least 150 psi or twice the required grout pressure, whichever is greater.

2.04 CEMENT GROUT:

A. Grout for grouting anchors shall consist of a homogenous, pumpable, stable mixture of Portland cement and water. Submit the proposed mix design to the Engineer for review. The water content shall be the minimum necessary for proper placement, but the water-cement ratio shall not exceed 0.45 by weight. Do not use accelerators.

B. Final proportions of materials shall be based on results of tests made on sample mixtures of grout. The minimum compressive strength of 2-inch cubes, molded, cured, and tested in accordance with ASTM C109, shall be 5,000 psi.

2.05 ANCHOR FABRICATION:

A. General:

1. Fabrication of the anchors shall be as recommended by the manufacturer/supplier. Anchors shall be completely assembled.

2. Fabricated anchors shall be protected, transported and stored in a manner to prevent corrosion or damage to any components.

PART 3 - EXECUTION

3.01 DRILLING HOLES:

A. General:

1. Holes shall be drilled at the locations shown and to the depths and diameters indicated. The locations of the holes may be changed only as approved by the Engineer.

2. The Contractor shall determine the drilling method to be used.

3. Wastewater from drilling operations shall be collected and disposed of off-site in accordance with Federal, State and local requirements; it shall not be discharged directly into the river.

B. Alignment:

1. Tolerances:

a. The anchor hole shall be located within 3-inches of the location shown in the Drawings. The entry angle shall be within 5 degrees of the specified inclination. If the hole alignment does not meet the specified tolerances, notify the Engineer immediately.

2. Alignment Check:

a. Check each drilled hole for alignment as specified herein upon completion of drilling and before commencement of any other work.

3.02 INSTALLATION OF ANCHORS:

A. General:

1. The Contractor is responsible for each drilled hole until the anchor has been installed and grouted.

2. Install anchors per the manufacturer's instructions, as indicated on the Drawings, and as described herein.

3. Anchor installation shall be completed using only application specific tools approved by the anchor manufacturer for this specific application.

4. All the equipment used in handling and placing the anchors shall be such that it does not damage or deteriorate the anchor. Each anchor shall be inspected prior to insertion into the hole.

B. Grouting:

1. Grout the anchor only after it has been fully embedded

2. Grout the anchor from the lowest gravitational point.

3.03 FIELD QUALITY CONTROL:

A. General:

1. The first three anchors will be pull tested and a minimum of three additional anchors will be pull tested. The Test Load shall not be exceeded.

2. Provide a qualified engineer to evaluate the anchor test results and determine the acceptability of the anchors in accordance with the criteria indicated hereunder. All tests shall be run in the presence of the Engineer or applicable representative.

B. Pull Test:

1. The Contractor shall hire an Independent Testing Agency to test all the rock anchors in accordance with ASTM E488. Use incremental loading for tensile test up to the service design load per anchor as indicated on the Contract Drawings. Consider anchors to have failed if displacement exceeds 0.1 inch or if any failure modes occur.

2. Report the results of all tests and inspections conducted at the project site. Submit test results within 24 hours of physical completion of testing. Do not place or install materials without prior approval.

C. Driller Logs:

1. The Contractor shall submit drilling logs to the Engineer. Separate logs shall be made for each hole. The following information shall be included in the logs or in the records for each hole:

a. Hole number or designation and location at the structure for the start of the drilled hole.

b. Diameter, depth, and inclination of hole.

D. Anchor Records:

1. Upon completion of installation of each anchor, the anchor records shall be submitted to the Engineer. The following information shall be included in the records for each anchor:

a. Report pull test results.

b. The pull test results shall include measured lengths of drill holes and anchors, the loads and elongations recorded during testing, and graphs of test results.

c. In addition, as-built drawings showing the completed installation of the anchors shall be furnished upon completion of installation of all anchors.

3.04 ACCEPTANCE:

A. Replacement of Rejected Anchors

1. Any anchor that fails the pull test or is rejected shall be replaced. A replacement anchor, including potentially a new anchor hole, shall be provided by the Contractor at no expense to Maine DMR. Provide all materials, supplies, equipment, and labor necessary to provide a new anchor assembly. No drilling shall be performed for a replacement anchor until the grouting of all adjacent

anchors of the replacement anchor location has been allowed to set for at least 24 hours. Payment will not be made for rejected or failed anchors.

END OF SECTION

SECTION 32 15 00

ACCESS ROADS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section includes the materials and installation for access roads as shown on the Drawings.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. 31 23 01: Earthwork and Rock Excavation.

B. 32 90 10: Site Restoration.

1.03. SUBMITTALS

A. Submit laboratory test report and material certifications verifying that the materials intended for use on the project conform to the requirements specified in this Section.

B. The Contractor shall be responsible for tests to ascertain that material proposed to be incorporated into the work meets the requirements of the Contract Documents. Acceptance or rejection of fill materials and compaction of fill will be based on the results of laboratory testing. Testing is to be performed by an independent testing laboratory and paid for by the Contractor.

1.04. REFERENCE STANDARDS

A. ASTM D698: Laboratory Compaction Characteristics of Soil Using Standard Effort (Standard Proctor).

B. Maine Department of Transportation (MDOT), Standard Specifications, latest edition.

1.05. EXISTING CONDITIONS

A. An existing storm drain system is located near the existing roadway and the new access road. Replace existing storm drain system in-kind as needed to construct the new bridge abutments, retaining walls, and access road. Coordinate Work with Woodland Pulp.

B. Protect the existing 36” pipe during construction.

PART 2 - MATERIALS

2.01. ACCESS ROAD

A. Access road construction shall consist of the following layers:

1. 12" minimum grub line, remove all stumps and organic material.
2. 12" minimum sub-base layer compacted MDOT Type D Gravel.
3. 12" base layer compacted MDOT Type A Gravel.
4. 3" (19mm) MDOT 50 Gyration HMA design base course.
5. 2" (12.5mm) MDOT 50 gyration HMA design wearing course.

PART 3 - EXECUTION

3.01. GENERAL

A. Refer to Section 31 23 01 Earthwork and Rock Excavation regarding excavation, subgrade preparation, and structural fill.

3.02. BACKFILL

A. Do not backfill against walls or other earth retaining structures until concrete has reached specified 28-day compressive strength and all load bearing supports, upper slabs, and footings are in place and cured to specified 28-day compressive strength.

B. Place fill evenly on all sides of grade beams, walls, and structures or provide bracing.

C. Retaining Walls: Refer to Division 03 Concrete specifications and the Drawings.

3.03. ROAD MATERIAL PLACEMENT

A. Road materials shall be placed in the location and to the depths indicated on the Drawings. Each layer shall not be placed until the previous sub-layer has been accepted by the Engineer.

B. Place layers horizontally and compact each layer in a methodical and consistent manner. Achieve the proper compaction of each layer prior to placing additional fill. Control moisture for each layer as necessary to meet requirements of compaction.

C. Place road materials in maximum loose lifts of six-inches and compact with an approved compactor.

D. Access road base layers shall be compacted to a density of not less than 98% of the maximum Standard Proctor (ASTM D698).

E. Access road shall be to the grades and slopes per the Drawings.

F. Rework any materials that have not been placed in accordance with these Specifications. Reworking may include removal, reconditioning, recompacting or combinations of these procedures, as required by the Engineer and at no additional cost to Maine DMR.

END OF SECTION

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SECTION 32 31 12

SECURITY FENCE

PART 1 - GENERAL

1.01 SCOPE:

A. These specifications are intended to cover the material, fabrication, and installation of the material required for the construction of chain-link security fence.

1.02 REFERENCES:

A. Codes:

1. The security fence of this specification shall be in compliance with the security and safety requirements of the current edition of the National Electrical Safety Code (NESC) and OSHA 1910.303.

2. WLD 2445, Chain Link Fence Wind Load Guide for the Selection of Line Posts and Spacing.

B. American Society for Testing and Materials International (ASTM):

1. A121: Standard Specification for Zinc Coated Steel Barbed Wire.

2. A392: Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.

3. F567: Standard Practice for Installation of Chain-link Fence.

4. F1043: Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated Welded for Fence Structures.

1.03 DESIGN CRITERIA:

A. Wind loads: 107 mph (3-second gust), Exposure C, per ASCE 7.

B. See Specification Section 01 81 10 Snow, Wind, and Seismic Design Criteria.

1.04 SUBMITTALS:

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit manufacturer’s descriptive literature and drawings of fence and gate installation.

C. Submit manufacturer’s certificate or original shipping tags showing compliance with cited U.S. Federal and ASTM specifications.

PART 2 - PRODUCTS

2.01 FABRIC AND WIRE:

A. Chain Link Fabric: shall be 84” high, 9-gage, 2x2-inch mesh. Fabric shall be galvanized with 1.2 oz coating meeting ASTM A392 Class 1. Secure to posts with 9-gauge steel fabric ties spaced at 12” on center maximum. Provide 7-gage bottom tension wire and three strands of 12½ gauge, 4 point barbed wire, 5” spaced barbs, on one-piece outward leaning steel extensions at top. All wire and components to be galvanized steel.

2.02 POSTS:

A. All posts shall be schedule 40, steel pipe (ASTM F1043 Group 1C, Fy = 50,000 psi), with hot-dipped galvanized finish. Minimum post sizes are listed below:

	Open Fabric	**Privacy Fabric**	**Notes**
Line Posts:	2 3/8" OD	2 7/8" OD	Complete with fabric clips, fittings for top rail, and 45 degree angle brackets for barbed wire bracket and necessary bracing members.
Corner/End Posts:	2 7/8" OD	3 1/2” OD	Complete with tension bar, fabric bands, top rail fittings, 45 degree barbed wire bracket and necessary bracing members.
Gate Posts:	6 5/8" OD	6 5/8" OD	Complete with all necessary fittings, caps, fabric bands, brace bars, and truss rods for use with gate listed below.
Top Rail:	1 5/8" OD	1 5/8" OD	

2.03 GATES:

A. Refer to Contract Drawings for location and type of gates.

Walk Gate: Single leaf, framed with 1-7/8" OD galvanized pipe. Gates are to be complete with all necessary fittings, hinges, and latches, with three strands of galvanized barbed wire on top. Gate fabric to match fence fabric listed above. A hold open keeper is not required.

2.04 FOOTINGS:

Concrete: Post Mix. (f'_c = 2500 psi)

Sack Size	**Initial Water**	**Final Water***
80 lb sack	6 pints/sack	6 - 9 pints
60 lb sack	4 pints/sack	4 - 7 pints
40 lb sack	3 pints/sack	3 - 4.5 pints

* Mix to achieve a maximum slump of 4 inches.
Concrete to be mixed prior to placing in hole.

Minimum Size:

	Open Fabric	**Privacy Fabric**
Line Post	12” Dia x 3’-0”	16” Dia x 3’-0”
End/Corner Post	12” Dia x 4’-0”	16” Dia x 4’-0”
Gate Post	16” Dia x 4’-0”	20” Dia x 4’-0”

Post Embedment: Line Posts = 2’-6” minimum in concrete footing
End/Corner/Gate Posts = 3’-0” minimum in concrete footing

PART 3 - EXECUTION

3.01 PREPARATION:

A. Verify areas to receive fencing including location of all corner posts.

B. Examine soil and environmental conditions under which fencing and gates are to be installed. Notify Woodland Pulp and the Engineer of unsatisfactory conditions. Do not proceed with work until conditions are satisfactory to the installer.

3.02 INSTALLATION:

A. Fence shall be installed along a straight and true line as defined by the drawings.

B. The top rail of the finished fence shall be 7’-0” above rough grade (6’-6” above finished grade). Bottom of fence fabric shall not be more than 2” above rough grade.

C. Holes for footing shall have a bottom diameter equal to or larger than the top diameter. Holes that taper are not acceptable.

D. Line posts shall be equally spaced between corner and gate posts. Spacing between line posts shall not exceed 8’-0” for chain link fabric.

E. Posts shall be installed plumb, in line with corner posts, and centered in the concrete footings. Concrete shall be placed in a continuous pour to a level even with the rough grade and shall not be allowed to “mushroom” over. Trowel finish to slope away from post.

F. Hinge connection to gate posts shall be bolted. Use Bulldog or similar type hinge. Welding hinges to gate post will not be acceptable.

G. Gates shall be hung plumb and true with not more than 10” of clearance over rough grade. Gates shall be installed in line with fence and swing freely into and out of the yard.

H. The maximum clear distance between gate posts and gate panel frame or between panels of double drive gates shall not exceed 4”.

I. The Contractor shall be responsible to field verify all elevations and dimensions shown in the Construction Drawings prior to the performance of the Work.

END OF SECTION

SECTION 32 34 00

FABRICATED BRIDGES

PART 1 – GENERAL

1.1 DESCRIPTION:

A. Fully engineered and prefabricated access bridges and security gates for accessing the area near the new fish lift.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. 01 81 10: Snow, Wind, and Seismic Design Criteria.

B. 32 15 00 Access Roads.

C. 32 31 12: Security Fence.

D. 09 90 00: Painting and Coating.

1.3 DEFINITIONS:

A. Definitions:

1. Contractor is directly contracted with Maine DMR for construction of the overall Project.

2. Engineer is the Engineer of Record for the overall Project or a representative for the Engineer of Record for the overall Project.

3. Manufacturer or Bridge Manufacturer includes the prefabricated bridge designer, fabricator, manufacturer, and suppler.

1.4 REFERENCES:

A. The following is a list of standards that may be referenced in this Section:

1. American Institute of Steel Construction (AISC):

a. 360-5: Specification for Structural Steel Buildings.

2. American Welding Society (AWS):

a. D1.0 - Code for Arc and Gas Welding in Building Construction.

b. D1.1 - Structural Welding Code - Steel.

3. American Association of State Highway and Transportation Officials, (AASHTO).

   a. Standard Specifications for Highway Bridges.

4. American Society for Testing and Materials (ASTM):

   a. A36: Standard Specification for Carbon Structural Steel.

   b. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

   c. A242: Standard Specification for High-Strength Low-Alloy Structural Steel.

   d. A307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.

   e. A606: Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance.

   f. A847: Standard Specification for Cold-Formed Welded and Seamless High Strength, Low Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance.

   g. F3125: Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

1.5 SUBMITTALS:

A. Bridge design shall be performed by a Registered Professional Engineer who is an employee of the Bridge Manufacturer and shall have a minimum of 5 years of experience designing steel vehicular bridges.

   1. The bridge design engineer shall provide signed and sealed design drawings and structural calculations for design review and approval. Include diagrams of design loading and permissible live loads.

   2. Submit bridge reactions, dimensions, bridge seat elevations, and anchor bolt locations at least 30 calendar days prior to the start of bridge foundation/abutment construction.

B. Shop Drawings:

   1. Detailed fabrication and installation drawings for access bridge sections and bridge bearing connections; include the following:

a. All dimensions, sizes, materials, finishes, fasteners, and welds.

b. Clearly indicate all field connections including bearing locations and anchor bolt locations.

c. Reference ASTM designations and grades where appropriate.

d. Provide installation recommendations.

C. Statement of Qualifications:

a. Bridge designer.

b. Bridge fabricator.

D. Quality Control:

1. Manufacturer’s Certificate of Compliance.

2. Certification from the Bridge Manufacturer that all design and material requirements specified herein are being met.

3. Manufacturer’s Certificates of Proper Installation

1.6 QUALIFICATIONS:

A. Bridge design documents shall be signed and sealed by a Professional Engineer licensed in the State of Maine.

B. Bridge supplier must have at least 10 years' experience in designing and fabricating these types of vehicular bridges and a minimum of 10 successful bridge projects of similar style and construction as specifically written in these specifications and the Contract Drawings. Reference projects shall list the location, bridge size, owner, and a primary contact for reference for each project.

C. Welders shall be experienced operators, properly qualified in accordance with applicable AASHTO and AWS standards.

1.7 QUALITY ASSURANCE:

A. Shop Testing and Assembly:

1. Welding procedures: Conform to AWS D1.1.

2. Perform visual and ultrasonic testing of all welds in accordance with AWS D1.1.

1.8 WARRANTY:

A. Warrant materials and installation for a minimum period of 10 years after the date of Woodland Pulp and Maine DMR's final acceptance of Work.

PART 2 - PRODUCTS

2.2 GENERAL:

A. The bridges shall be prefabricated steel bridges.

B. Bridge Suppliers/Manufacturers:

1. Acrow Corporation of America

2. Big R Bridge Manufacturing

3. Continental Bridge

4. Steadfast Bridge Company

5. Contech Engineered Solutions

C. The security gate on the access bridge shall be 6 feet high and completely restrict access to the fish lift (island) side of the bridge. Security gates shall be lockable per Woodland Pulp (property owner) standards.

2.3 GEOMETRY:

A. The bridges shall be one lane with a minimum inside clear width of 13-feet.

B. Bridge spans shall be as shown on the Contract Drawings:

1. Bridge No. 1 Span = approximately 160 feet.

2. Bridge No. 2 Span = approximately 67 feet.

C. Minimum camber at the center of the bridge shall be 100-percent of the full dead load deflection plus 1-percent of the total span length.

D. In addition to vehicular guard rail, bridges shall include fencing or railing to allow pedestrians to safely use the bridge.

1. Minimum railing height shall be 42 inches above the finished bridge deck.

2. The pedestrian safety rails, pickets, or fencing shall be spaced to prevent a 4-

inch sphere from passing through.

3. All accessible surfaces shall be free of sharp edges and means to prevent bridge users from cutting or scraping themselves.

2.4 ENGINEERING:

A. The access bridges shall be designed to meet the following criteria:

1. Design Load: AASHTO HS-25

2. Thermal loads shall be based on a minimum temperature differential of 120 degrees Fahrenheit, with installation assumed to be at 60 degrees Fahrenheit.

3. Wind load: 35 pounds per square foot on the full height of the bridge and 20 pounds per square foot upward force applied at the windward quarter point of the transverse bridge width in accordance with AASHTO Standard Bridge Specifications.

4. Overturning Forces : The effect of forces tending to overturn structures shall be calculated assuming that the wind direction is at right angles to the longitudinal axis of the structure.

5. Seismic Loading: Refer to Specification Section 01 81 10 Snow, Wind, and Seismic Design Criteria.

6. Bridge Rail: Designed to meet the forces of TL-2 (not crash tested).

7. Bridge pedestrian safety rails, picket system, or fencing shall be designed for the following:

   a. Infill loading of 200 pounds applied horizontally at right angles to a one square foot area at any point in the system.

   b. 50 pounds per lineal foot or a 200 pound point load, whichever produces greater stresses, applied in any direction at any point along the top chord or at the top of the safety system.

8. Maximum live load bridge deflection shall not exceed 1/400 of the span. The deflection of the floor system (floor beams, stringers, decking) due to pedestrian live load shall not exceed 1/360 of their respective spans.

B. Bridge Foundations, Piers, and Abutments:

1. Bridge foundations, piers, and abutments shown on the Contract Drawings were designed based on preliminary bridge loads, reactions, and dimensional

information. The preliminary bridge reactions are summarized below.

Reactions ***(Per corner of bridge)*** **- PRELIMINARY -**

LOADS	Unfactored reactions
DL1 (EW + TSR3SH + TL_2 Guardrail)	59
DL2 (Epoxy Coating)	2
HS25-44 Truck	0
HS25-44 Lane	58
Permit Truck	0
Pedestrian Live Load	0
TOTAL	**119**
WIND	**25**

NOTE: All reactions are per corner of bridge, except those resulting from the Wind Load, which are per end of bridge
All values are in kips (1,000 lbs)
Eccentricity (Ecc.) is included in the calculation of reactions
Impact (I) is not included in the calculation of reactions
Reduction in Load Intensity (RLI) is included in the calculation of reactions

2. If any of the design loads or reactions calculated for the prefabricated bridge proposed by the Contractor exceed those presented above, the Contractor shall notify the Engineer immediately to allow for the foundations/piers/abutments to be re-evaluated and potentially redesigned.

3. If redesign of the foundations, piers, or abutments is needed, do not begin fabrication of the bridge or construction of the structural elements until the Engineer has completed the redesign.

4. Geometry:

   a. As much as practical, the superstructure depth from bridge deck surface to bottom of steel shall be maintained as indicated on the Contract Drawings for each individual bridge.

   b. As much as practical, the bridges shall be manufactured with superstructure elevations to comply with the Contract Drawings.

5. Notify the Engineer as soon as possible if modifications are needed to the bridge foundations/piers/abutments and back-wall design shown in the Contract Drawings.

2.5 MATERIALS:

A. Bridges shall be fabricated from self-weathering structural steel tubing conforming to the requirements of ASTM A847, or self-weathering structural steel rolled shapes, or plates conforming to the requirements of ASTM A36, A242, A588, or A606.

B. Deck: Steel plate decking with epoxy aggregate, anti-skid surface or other decking material accepted by the Engineer and Woodland Pulp. The deck design shall be performed by the Bridge Manufacturer.

C. Structural Fasteners: All bolted connections shall utilize ASTM F3125 High Strength Structural Bolts. Type 3 bolts are required for weathering steel bridges. Type 1 hot dip galvanized bolts are required for painted and galvanized bridges. Hot dip galvanizing shall be in accordance with ASTM A153 specifications.

D. Anchor bolts shall be ASTM A307 or ASTM F3125 bolts. Anchor bolt size and type shall be as recommended by the prefabricated Bridge Manufacturer. Decking fasteners and bolts shall be hot-dipped galvanized.

2.6 FABRICATION:

A. Workmanship, fabrication and shop connections shall be in accordance with AASHTO and AISC specifications.

2.7 FINISH:

A. Bridge components constructed of self-weathering steel shall be cleaned in accordance with Steel Structures Painting Council Surface Preparation Specification No. 7. (SSPC-SP- 7 brush-off blast cleaning).

B. All exposed surfaces and components of the bridge that are not constructed of self-weathering steel shall be finished in accordance with the requirements of Specification Section 09 90 00 Painting and Coating.

2.8 HANDRAILS:

A. Handrails shall be provided on both sides of the bridge along its entire length.

2.9 SECURITY FENCE/GATE:

A. The security fence/gate shall be chain link with barbed wire around the perimeter.

B. Refer to Specification Section 32 31 12 Security Fence.

PART 3 - EXECUTION:

3.1 DELIVERY AND ERECTION:

A. Bridges will be delivered by truck to a location nearest to the site accessible by roads. Hauling permits and freight charges are the responsibility of the Manufacturer.

B. The Manufacturer will notify the Contractor and Woodland Pulp in advance of the expected arrival time.

C. The Manufacturer will advise the Contractor of the actual lifting weights, attachment points and all necessary information to install the bridge.

D. Unloading and erecting the prefabricated bridge shall be completed in accordance with the Bridge Manufacturer's recommendations.

E. The Contractor shall install the anchor bolts in accordance with the Manufacturer's anchor bolt spacing dimensions.

3.2 MANUFACTURER'S SERVICES:

A. A Manufacturer's representative must be present at the Project site while the primary structure components are installed. Provide Manufacturer's representative on site to:

1. Inspect installation.

2. Certify that bridge has been installed in accordance with Manufacturer recommendations and meets Specification requirements.

B. The Contractor shall notify the Manufacturer or their representative at least 2 weeks in advance of the planned installation.

3.3 OTHER:

A. Refer to the Contract Documents and Specification Section 32 15 00 Access Roads for all roadway approach work.

B. All grounding and lightning protection shall be coordinated with Woodland Pulp.

3.4 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 32 90 10

SITE RESTORATION

PART 1 - GENERAL

1.01. DESCRIPTION

A. This Section describes materials, installation, and procedures for surface restoration at the Site including surface conditions, reseeding, and weed control.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. 01 40 00: Quality Requirements.

B. 31 23 01: Earthwork and Rock Excavation.

1.03. SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Submit copies of the seed mixes to be used.

C. Submit manufacturers' product data and MSDS sheet of herbicides to be used to control weeds.

1.04. PERFORMANCE STANDARDS

A. Surface restoration shall be considered successful when there are indications that the native vegetation from the topsoil and applied seed is recovering. In addition, the site shall show resistance to invasive weed species.

B. Project surface restoration shall be considered successful when more than 70 percent is covered by vegetation specified herein, i.e., not weeds, invasive species, etc.

PART 2 - MATERIALS

2.01. SEED MIXES

A. A vegetation survey in the area that will be affected by construction will be completed by the Contractor and reviewed by Woodland Pulp and Maine DMR prior to construction.

B. Seed mixes shall be selected to match the conditions where they will be used. Seed mixes for vegetative reclamation can be determined using the vegetation survey, by using pre-made mixes intended for use in specific areas, or by using the property owner's requested blend.

2.02. GRAVEL ROADS AND DRIVEWAYS

A. The Contractor shall replace gravel surfacing on a satisfactory compacted backfill with road base conforming to compacted 3" (19mm) MDOT 50 Gyration HMA design base course and 2" (12.5mm) MDOT 50 gyration HMA design wearing course.

B. Refer to Section 32 15 00 Access Roads for additional requirements.

2.03. WEED MANAGEMENT

A. Utilize the Integrated Weed Management (IWM) concept to control weeds. IWM is a comprehensive management concept that utilizes a combination of weed control techniques to control weeds as appropriate. These methods could include manual removal, mechanical control, and chemical control.

2.04. CHEMICAL WEED CONTROL

A. Only herbicides that are U.S. Environmental Protection Agency (EPA) approved for aquatic environments shall be used. These herbicides shall include unrestricted glyphosate without a surfactant, such as Dow AgroSciences Rodeo® and Accord®, Monsanto AquaMaster™, or 2,4-D Amine. Contractor shall apply all herbicides in accordance with applicable laws.

PART 3 - EXECUTION

3.01. RESTORATION OF NON-PAVED AREAS

A. General

1. The Contractor shall remove excess soil and rock from the site, rough-grade disturbed areas, and replace topsoil within two weeks of final grading.

2. Regrade as necessary to match existing contours and to promote proper drainage.

B. Subgrade Preparation

1. The Contractor shall rip subsoil and/or till the subgrade prior to placement of topsoil.

a. Ripping shall consist of disturbing the soil to a depth of nine-inches with long narrow tines or a sub-soiler-type plow without inverting (overturning) the soil.

2. All disturbed areas requiring topsoil replacement, shall have the subgrade tilled to a depth of six-inches. Tilling shall consist of loosening the subgrade by scarifying and/or disking.

3. After tilling the subgrade, surface rocks three-inches and larger shall be removed by a rock picker or other mechanical means, e.g., manually. Areas that have also been ripped, shall have surface rocks three-inches and larger removed by a rock picker or other mechanical means.

C. Topsoil Placement

1. After subgrade tilling and rock removal, the topsoil shall be replaced and lightly compacted.

2. The topsoil shall be mechanically screened or picked of rocks two-inches and greater. Hand selecting rocks from the topsoil as it is placed will not be permitted in lieu of mechanical means of removal.

3. The depth of topsoil to be replaced shall be the same depth as determined during the preconstruction meeting with the property owner or six- inches, minimum. Topsoil shall be imported to replace the quantity of material removed during the rock screening process in order to achieve the original topsoil depth. If the original topsoil depth is less than six-inches, topsoil shall be imported to obtain the six -inch minimum depth.

4. A Standard Proctor Density of 85 percent for the top three-inches of topsoil is acceptable. The depth of topsoil replacement and soil amendment requirements, as deemed necessary by qualified soil technicians.

5. All disturbed and bare soil areas shall be reseeded with a suitable seed mix to ensure the establishment of revegetation.

3.02. RESTORATION OF PAVED AND CONCRETE AREAS

A. All paved and concrete areas, e.g., curbs, gutters, sidewalks, etc., that are disturbed as a direct result of excavation activities, as well as any areas damaged by heavy equipment activity, shall have pavement or concrete replaced in-kind.

3.03. RESTORATION OF GRAVEL ROADS AND DRIVEWAYS

A. All gravel surfaces that are disturbed as a direct result of excavation activities, as well as any areas damaged by heavy equipment activity, shall be resurfaced with road base per these Specifications.

B. The finished surface shall conform to the original grade, unless shown otherwise on the Drawings.

C. Refer to Section 32 15 00 for road materials and gravel surfacing requirements.

3.04. STABILIZATION OF SLOPED SURFACES

A. All exposed slopes and stream banks shall be immediately stabilized upon completion of each crossing. If determined to be necessary by the Engineer, non-vegetative erosion control measures, such as erosion control mats or wattles, shall be installed to minimize potential damage caused by wind and water erosion.

B. Erosion control devices shall be free of non-native seed.

3.05. SEEDING

A. Prior to seeding, the seeding surface shall be scarified. Raking may be necessary. Seed shall be divided out by area and hand broadcast evenly over the impacted area. After broadcasting, the seed shall be lightly-raked into the soil with a landscape rake, or equivalent.

B. Seeding mixtures shall be sewn at the time of year specified for the mixture used. Seeding efforts shall be coordinated to occur within this window.

3.06. MULCHING

A. Mulch shall be placed after seeding is complete.

3.07. IRRIGATION

A. Although the restored plant community may not require irrigation, supplemental irrigation, via a water truck or other approved means, shall be applied if seasonal precipitation is below average or the revegetation is showing indications of stress.

3.08. WEED CONTROL METHODS

A. Weeds shall be reviewed monthly during the growing season and treated to achieve the performance standards.

B. Weeds shall either be chemically- or mechanically controlled. In areas where there is risk of damage establishing native species by chemical or mechanical methods, weeds shall be manually removed.

C. Chemical Control

1. Recommendations for the use of restricted herbicides shall be submitted to the appropriate jurisdictional entity, in writing, by a licensed Commercial Applicator or Qualified Supervisor. All restricted herbicide applications shall be approved by the jurisdictional entity prior to use. All herbicide shall be applied in accordance with Maine DMR regulations and label requirements. The following timing targets shall be used:

2. If chemical treatment is used, wick application or spot spraying shall be used to minimize effects to surrounding non-target species. If resistance to chemical control is determined, an alternate method of control shall be used.

3. Broadcast spraying shall be used with target selective herbicides when weed density is heavy and no non-target species are at risk of damage from drift.

4. Spot spraying shall be used when focus spraying can treat weeds without incidental damage.

5. Wicking shall be used in areas where highly aggressive weeds are among natives.

D. Mechanical Control

1. The mechanical control method used for this project shall consist of mowing with a weed whip. Mowing shall only be used on annual weed species at locations where weeds are relatively dense and are predominantly taller than the other native species.

E. Manual Removal

1. Weeds shall be manually removed when chemical or manual control methods are impractical or could cause damage to surrounding native vegetation. All material resulting from manual removal shall be legally disposed of offsite. Special care shall be taken to make sure that all potentially viable seed heads are carefully bagged and removed from the site.

3.09. OTHER RECLAMATION MAINTENANCE ITEMS AS REQUIRED BY WOODLAND PULP

A. These items may include reseeding in areas where vegetation efforts are suffering, regrading due to heaving or settling, and erosion, and erosion and sedimentation control maintenance.

END OF SECTION

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SECTION 33 11 00

GENERAL PIPING COMPONENTS AND REQUIREMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section describes the requirements for flange gaskets, flange assembly studs, nuts, and washers and flange isolation kits for piping, fittings, valves, and other equipment.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. Painting and Coating: 09 90 00.

B. Flexible Pipe Couplings and Expansion Joints: 33 11 02.

C. Valves for Waterworks: 33 12 16.

D. Carbon Steel Pipe: 40 20 55.

1.03. REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. A193: Standard Specification for Alloy-Steel and Stainless-Steel Bolting Materials for High-Temperature Service.

2. A194: Standard Specification for Carbon Steel, Alloy Steel, and Stainless-Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

3. F436: Standard Specification for Hardened Steel Washers Inch and Metric Dimensions.

1.04. SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit certified copies of mill test reports for studs, nuts, and washers including specified coatings. Provide recertification by an independent domestic testing laboratory for materials originating outside of the United States.

C. Submit manufacturer's catalog literature and product data sheets for flange gaskets showing dimensions and bolting torque recommendations.

D. Submit manufacturer’s catalog literature and product data sheets for flange isolation kits.

E. Submit affidavits of compliance with referenced standards.

PART 2 - MATERIALS

2.01. FLANGE STUDS, NUTS, AND WASHERS

A. Studs shall conform to ASTM A193, Grade B7, with heavy hex nuts conforming to ASTM A194, Grade 2H.

B. Minimum stud lengths shall be determined by adding the sum of the mating flange maximum thicknesses, the gasket, washers, and depth of the nut plus ¼-inch minimum.

C. Provide washers for each nut in accordance with ASTM F436. Washers shall be of the same material as the nuts.

D. Threads shall be formed by means of rolling, not cutting or grinding.

2.02. FLANGE GASKETS

A. Flange gaskets shall be ring, 1/8-inch thick and formulated from non-asbestos materials.

B. Flange gaskets shall have “nominal pipe size” inside diameters.

C. Manufacturers: Garlock MULTI-SWELL Style 3760 or approved equal.

2.03. FLANGE ISOLATION KITS

A. Isolation Flange Gaskets

1. Flange isolation gasket shall be compressed aramid fiber (non-asbestos) with SBR binder, full faced and 1/8-inch thick.

2. Manufacturers: Garlock 3200 or approved equal.

B. Sleeves and Washers

1. Provide full length G-10 sleeves with G-10 washers. Only two-piece washer and sleeve combinations are allowed due to torque loads.

2. For above grade isolation flange applications, install double washer sets.

3. Manufacturer: GPT Industries or approved equal.

PART 3 - EXECUTION

A. FLANGED PIPE ASSEMBLY

B. Assemble flanged pipe without forcing or stressing the pipe, adjacent connecting pipe, valves, or other equipment.

C. Before bolting up, clean flanges by wire brushing and align the flange faces to the design plane to within 1/16-inch and align the flange bolt holes to within 1/8-inch maximum offset.

D. Examine studs, nuts, and washers for defects such as burrs, cracks, and rust. Inspect each flange gasket to verify that it is the correct size, material, and type for the specified service and that it is clean and undamaged. Replace as needed.

E. Place gasket between flange faces aligning the gasket and flange bolt holes, insert studs, and tighten nuts. Do not use more than one gasket between flange faces. Tighten the studs to the manufacturer's specifications, using the recommended cross-bolting pattern in multiple steps of increasing torque, until the final torque requirements are achieved. Do not over torque.

F. Stud lengths shall extend completely through their nuts. Studs that extend through their nuts by one or more threads will be considered completely engaged. Assembled studs and nuts not meeting this requirement will be rejected.

G. Install pipe supports per the Construction Drawings to sufficiently support piping in exposed installations, e.g., piping/fittings/valves located above ground.

3.02. PAINTINGS AND COATINGS

A. Coat entire flange assemblies in exposed service, including studs and nuts, per Section 09 90 00.

3.03. TESTING

A. If flanges leak under pressure testing, loosen or remove the studs and nuts, reset or replace the gasket, reinstall or retighten the studs and nuts, and retest the joints. Joints shall be watertight.

END OF SECTION

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SECTION 33 11 02

FLEXIBLE PIPE COUPLINGS AND EXPANSION JOINTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes materials and installation of flanged dismantling joints and expansion joints.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Paintings and Coatings: 09 90 00.

B. General Piping Components and Requirements: 33 11 00.

C. Carbon Steel Pipe: 40 20 55.

D. Field Hydrostatic Leakage Testing: 33 14 00.

1.03 REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. A36: Standard Specification for Carbon Structural Steel.

2. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. A193: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

4. A194: Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

5. A283: Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

6. A536: Standard Specification for Ductile Iron Castings

B. American Waterworks Association (AWWA)

1. C111: Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

2. C207: Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)

3. C221: Fabricated Steel Mechanical Slip-Type Expansion Joints

1.04 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit manufacturer's catalog data for dismantling joints and expansion joints. Show manufacturer's model or figure number for each type of joint and for each type of pipe diameter for which dismantling joints and expansion joints are used. Provide coating and lining data.

C. Submit manufacturer's recommended torques to which the coupling bolts shall be tightened for the flexible gasketed sleeve-type compression pipe couplings.

D. Show materials of construction by ASTM reference and grade. Show dimensions.

1.05 LABELING OF EQUIPMENT

1. Expansion joints and dismantling joints shall be listed and labeled in accordance with Woodland Pulp standards.

PART 2 - MATERIALS

2.01 COUPLING SYSTEM DESIGN AND COMPONENT UNIT RESPONSIBILITY

A. The coupling manufacturer shall furnish the gaskets, bolts, nuts, glands, end rings, and hardware for pipe couplings of all types and shall design and supply these components as an integral system. Design the gaskets for the coupling and appropriately size to provide a watertight seal at the design pressure and temperature. Ship gaskets, bolts, nuts, glands, end rings, and hardware for pipe couplings with the pipe coupling and clearly label indicating the origin of the material, including place and date of manufacture. Package the manufacturer's printed installation instructions with each pipe coupling.

2.02 DISMANTLING JOINTS

A. Dismantling joints shall consist of a flanged steel spigot piece, a flanged sleeve, a center ring welded onto the sleeve, and a follower ring containing a gasket through which the spigot piece slides into the sleeve. The joint shall accommodate longitudinal movement. The longitudinal adjustability shall be provided by a telescopic action of a flanged spigot and associated sleeve, which inserts into the spigot. A system of tie bolts or rods shall connect the end flange on the sleeve to the end flange on the spigot piece. Provide washers and nuts on the tie bolts on both sides of the sleeve and flange and the spigot end flange to allow for adjustment of the extension length for the sleeve.

B. The minimum design pressure shall be the same as the adjacent piping. Design stresses shall not exceed 40% of the yield strength of the materials. Minimum factory test pressure shall be 150% of the design pressure.

C. The gasket shall be compressed by a separate bolting and gland system, independent of the tie bolts. Gasket shall be EPDM.

D. Dismantling joints shall have a spigot piece made of steel conforming to ASTM A36, A53 (Type E or S), or A283, Grade C having a minimum yield strength of 30,000 psi and a flange adapter and follower ring made of ductile iron conforming to ASTM A536, Grade 65-45-12.

E. Sleeve and follower ring bolts shall have a minimum yield strength of 105,000 psi, a minimum tensile strength of 125,000 psi, and shall conform to ASTM A193, Grade B7.

F. Nuts shall be heavy hex nuts conforming to ASTM A194, Grade 2H.

G. Steel flanges and gasket follower rings shall be cast, forged, or hot rolled in one piece. Do not use flanges or rings fabricated from two or more shapes. Flanges shall conform to ANSI Classes 125 and 150.

H. Wall thickness of spigot piece and sleeve shall be at least that specified for the size of pipe in which the coupling is to be used.

I. Manufacturers: Romac Industries Style DJ400, Smith-Blair 975, or Baker.

2.03 EXPANSION JOINTS

A. Expansion joints shall be single end with no limit rods, meet the requirements of AWWA C221, and be designed for ten (10) inches of movement (total travel).

1. Body: ASTM A36 Carbon Steel
2. Slip Pipe: Type 304 Stainless Steel
3. Packing: Alternating combination of rubber (NBR) and impregnated flax packing.
4. End Preparation: AWWA C207 Class D flange
5. Bolts and Nuts: High Strength low alloy steel bolts and nuts meeting AWWA C111.
6. Coating: Manufacturer applied fusion bonded epoxy.

B. Acceptable Manufacturers: Romac EJ401 or approved equal.

2.04 BOLTS, NUTS, AND WASHERS FOR FLANGES

A. Refer to Section 33 11 00.

PART 3 - EXECUTION

3.01 SHIPMENT AND STORAGE OF FLEXIBLE PIPE COUPLINGS AND EXPANSION JOINTS

A. Inspect on receipt for damage in shipment and conformance with quantity and description on the shipping notice and order. Unload carefully to the ground without dropping. Do not load or unload by inserting forklift tines or lifting chains inside the waterway. Use nonmetallic slings, padded chains, or padded forklift tines to lift items. Lift with eyebolts or rods through flange holes or chain hooks at ends.

B. Protect from weather and the accumulation of dirt, rocks, and debris. Do not expose rubber seats to sunlight or ozone for more than 30 days. Also, see the manufacturer's specific storage instructions.

C. Make sure flange faces, joint sealing surfaces, body seats, and disc seats are clean.

D. Expansion joints shall be assembled and shipped with the slip pipe in the closed (contracted) position. The slip pipe shall be properly positioned based on the temperature at the time of installation.

3.02 INSTALLATION OF DISMANTILING JOINTS

A. Clean oil, scale, rust, and dirt from pipe ends. Clean gaskets in flexible pipe couplings before installing.

B. Lubricate bolt threads with graphite and oil prior to installation.

C. The Engineer or responsible Owner representative shall inspect each coupling to ensure that there are no damaged portions of the coupling particularly the sealing pad / sealing plate area.

D. Before installation, each coupling shall be thoroughly cleaned of any foreign substance which may have collected thereon.

E. Do not spring flanges or ends of connecting piping into position. Separately work connecting piping system into position to bring the piping flanges or ends into alignment with the matching coupling flanges or joints. Do not move couplings to achieve piping alignment.

F. Line up pipe flange bolt holes with coupling or joint flange bolt holes within 1/16-inch maximum offset from the center of the bolt hole to permit insertion of bolts without applying any external force to the piping.

G. Flange face separation shall be within the gasket spacing ±1/16-inch. Use only one gasket per flanged connection.

H. Wrenches used shall be of a size and type recommended by the manufacturer. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact around the circumference of the pipe.

I. In no case shall the deflection in the joint between the pipe ends exceed the maximum deflection recommended by the manufacturer. No joint shall be misfit any amount that would be detrimental to the strength and water tightness of the finished joint.

3.03 INSTALLATION OF EXPANSION JOINTS

A. Check to make certain that the slip pipe is in the closed (contracted) position. Place reference marks on the body and slip pipe for positioning of slip pipe and loosen the bolts so that the slip pipe can be positioned.

B. The distance the slip pipe is to be withdrawn is calculated by the formula below:

$$Length\ to\ Withdraw\ Slip\ Pipe = \left(\frac{Max\ Operating\ Temp - Installation\ Temp}{Total\ Temperature\ Range}\right) \times (Total\ Travel\ \ of\ Joint)$$

Max Operating Temperature = 150^{o}F
Min Operating Temperature = -32^{o}F
Total Temperature Range = 182^{o}F
Total Travel of Joint = 10 inches
Installation Temperature – Temperature of adjacent pipe at time of installation.

C. Tighten the packing gland bolts to 5 – 10 foot pounds to hold the slip pipe in position.

D. As the pipeline is pressurized, tighten the packing gland bolts to compress the packing. Use sufficient torque to prevent leakage. Overtightening will cause premature packing wear.

3.04 PAINTINGS AND COATINGS

A. Line and interior and exterior surfaces per Section 09 90 00.

3.05 HYDROSTATIC TESTING

A. Hydrostatically test couplings in place with the pipe being tested. Test in accordance with Section 33 14 00.

END OF SECTION

SECTION 33 11 04

MODULAR MECHANICAL SEALS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes materials, installation, and testing of modular mechanical seals.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Concrete Joints and Accessories: 03 15 00.

B. General Piping Components and Requirements: 33 11 00.

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit detailed drawings and technical data for modular mechanical seals.

C. Submit manufacturer's instructions for installing modular mechanical sealing devices.

PART 2 - MATERIALS

2.01 MODULAR MECHANICAL SEALING DEVICES

A. Modular mechanical sealing devices shall utilize interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe sleeve and the passing pipe. Assembled links shall form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut.

B. Materials of construction shall be as follows:

Compound	**Material**
Pressure Plate	Carbon Steel, Type 304 or 316 Stainless Steel, or Delrin Plastic
Bolts and Nuts for Links	Type 316 Stainless Steel
Sealing Element	EPDM Rubber

C. The size of the wall sleeve needed to accommodate the passing pipe shall be as recommended by the modular mechanical sealing device manufacturer.

D. Provide centering blocks in 25% of the sealing elements on pipelines larger than twelve 12-inches in diameter.

E. The modular mechanical sealing devices shall be Pipeline Seal and Insulator, Inc. Link-Seal®, Advance Products & Systems, Inc. INNERLYNX®, or equal.

2.02 POLYETHYLENE FOAM FILLER FOR PIPE PENETRATIONS

A. Foam filler shall be an extruded, closed-cell polyethylene foam rod ½-inch larger in diameter than the annular space.

B. Polyethylene foam filler shall be W.R. Meadows KOOL-ROD™, Dow Chemical Company® Ethafoam™, or equal.

2.03 POLYURETHANE SEALANT FOR PIPE PENETRATIONS

A. Sealant shall be a multipart, polyurethane sealant, for continuous immersion in water. The sealant shall cure at ambient temperature.

B. Polyurethane sealant shall be Sika Corporation Sikaflex®-2C NS, or equal.

2.04 HYDROPHILIC CAULK

A. Hydrophilic caulk shall be in accordance with Section 03 15 00.

2.05 HYDROPHILIC WATERSTOP

A. Hydrophilic waterstop shall be in accordance with Section 03 15 00.

PART 3 - EXECUTION

3.01 INSTALLATION OF MODULAR MECHANICAL SEALING DEVICES

A. Install in accordance with the manufacturer's instructions.

END OF SECTION

SECTION 33 12 16

VALVES FOR WATER WORKS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section includes materials, testing, and installation of Contractor-furnished:

1. Valve Actuator.

2. Butterfly Valve.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. Painting and Coating: 09 90 00.

B. General Piping Components and Requirements: 33 11 00.

C. Flexible Pipe Couplings and Expansion Joints: 33 11 02.

D. Field Hydrostatic Leakage Testing: 33 14 00.

E. Electric Actuators for Valves: 40 92 10.

1.03. REFERENCES

A. American Water Works Association (AWWA):

1. C504: Rubber-Seated Butterfly Valves.

B. American Society for Testing and Materials International (ASTM):

1. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

2. A276: Standard Specification for Stainless Steel Bars and Shapes.

3. A351: Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

4. A666: Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, or Flat Bar.

1.04. SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit manufacturer's catalog data and detail construction sheets showing all valve parts. Describe each part by material of construction, specification (such as AISI, ASTM, SAE, or CDA), and grade or type.

C. Show valve dimensions including laying lengths. Show port sizes. Show dimensions and orientation of valve actuators, as installed on the valves. Show location of internal stops for gear actuators. State differential pressure and fluid velocity used to size actuators. For worm-gear actuators, state the radius of the gear sector in contact with the worm.

D. Show valve linings and coatings. Submit manufacturer's catalog data and descriptive literature.

1.05. LOCK OUT/TAG OUT

A. Butterfly valves must be lockable for lockout/tagout isolation purposes. Coordinate with Woodland Pulp.

1.06. LABELING OF EQUIPMENT

A. Butterfly valves shall be listed and labeled in accordance with Woodland Pulp standards.

PART 2 - MATERIALS

2.01 GENERAL

A. Install valves complete with electric actuators as required for operation.

B. Valves shall have the name of the manufacturer, and the size of the valve cast or molded onto the valve body or bonnet or shown on a permanently attached plate.

2.02 VALVE ACTUATORS

A. All valves shall open left (counterclockwise).

B. Valve to be supplied with electric actuator in accordance with Section 40 92 10.

2.03 BOLTS AND NUTS FOR FLANGED VALVES

A. Bolts and nuts for flanged valves shall be as described in Section 33 11 00.

2.04 GASKETS FOR FLANGES

A. Gaskets for flanged end valves shall be as described in Section 33 11 00.

2.05 PACKING AND O-RINGS:

A. Unless otherwise stated in the detailed valve specifications, packing and O-rings shall be one of the following non-asbestos materials:

1. Teflon.

2. Buna-N (nitrile, NBR).

3. EPDM

2.06 BUTTERFLY VALVES

A. Butterfly valves shall be rubber seated, short body, flanged type, conforming to AWWA C504, Class 150B (minimum), except as modified herein. Flanged ends shall be drilled per Class 125, ASME B16.1. Valve shafts shall be stub shaft or one-piece units extending completely through the valve disc. The rubber valve seats shall be secured to or retained in the valve body. Materials of construction shall be as follows:

Component	Material	Specification
Body	ductile iron	AWWA C504
Exposed body cap screws and bolts and nuts	Stainless steel	ASTM A276, Type 304 or 316
Discs	Stainless steel	ASTM A351 Grade CF-8M, Grade CN-7M
Shafts, disc fasteners, seat retention segments, and seat fastening devices	Stainless steel	ASTM A276, Type 316
Disc seating edge	Stainless steel	ASTM A240 or A666
Seat material	Buna-N or EPDM	--

1. Where AWWA C504 requires “corrosion resistant materials,” such materials shall be generically the same as those specified for the disc, shafts, disc fasteners and seat retention devices, and disc seating edge.

2. Provide thrust bearings to hold the valve disc in the center of the valve seat. No bearings shall be mounted inside the valve body within the waterway. Do not use thrust bearings in which a metal bearing surface on the disc rubs in contact with an opposing metal surface on the inside of the body.

3. Valves shall be Pratt, DeZurik Series BAW, Val-Matic, or approved equal.

B. Port Sizes for Butterfly Valves

1. The port diameter shall not be more than 1.25 inches smaller than the nominal valve size. The dimension of the port diameter shall be the clear waterway diameter plus the thickness of the rubber seat.

C. Corrosion-Resistant Materials in Butterfly Valves

1. Where AWWA C504 requires “corrosion resistant” material, such material shall be one of the following:

a. Bronze as described below.

b. Type 304 or 316 stainless steel.

c. Monel (UNS N04400).

d. Synthetic nonmetallic material.

D. Seating Surfaces in Butterfly Valves

1. Seating surfaces shall be stainless steel or nickel-copper per AWWA C504 or nickel-chromium alloy containing a minimum of 72% nickel and a minimum of 14% chromium.

E. Fluid Service Requirements for Butterfly Valves

1. Design valves for a temperature range of 0°F to 150°F.

2. Bronze components in contact with water shall comply with the following requirements:

Constituent	**Content**
Zinc	2% maximum
Aluminum	2% maximum
Lead	8% maximum
Copper + Nickel + Silicon + Iron	88% minimum

2.07 PAINTING AND COATING

A. Painting and coating for valve exteriors and interiors shall be as described in Section 09 90 00.

B. Flange faces shall be shop-coated with a rust preventive compound. Manufacturers: Houghton Rust-Veto 344, Rust-Oleum R-9, or approved equal.

2.08 FACTORY LEAKAGE TESTING

A. All valves shall be factory leakage tested using the valve and actuator assembly per AWWA C504 on both sides of the seat (both directions, 10 minutes min). Valve manufacturer shall mount actuator to valve.

PART 3 - EXECUTION

3.01 VALVE INSTALLATION

A. Valve seat and actuator shall be installed per the orientation indicated on the Construction Drawings.

3.02 MOUNTING GEAR ACTUATORS

A. The valve manufacturer shall select and mount the gear actuator and accessories on each valve and stroke the valve from fully-open to fully-closed prior to shipment.

3.03 FIELD INSTALLATION OF GEAR ACTUATOR

A. Provide the actuator manufacturer's recommended lubricating oil in each actuator before commencing the field testing.

3.04 FIELD APPLIED PAINTING AND COATING

A. Field painting and coating shall be as described in Section 09 90 00.

3.05 VALVE LEAKAGE TESTING

A. Test valves for leakage at the same time that the connecting pipelines are tested. See Section 33 14 00 for leakage testing requirements. Protect or isolate any parts of valves, actuators, or control and instrumentation systems whose pressure rating is less than the pressure test. Valves shall show zero leakage. Repair or replace any leaking valves and retest.

3.06 VALVE FIELD TESTING

A. Operate manual valves through three full cycles of opening and closing. Valves shall operate from full open to full close without sticking or binding. If valves stick or bind, or do not operate from full open to full closed, repair or replace the valve and repeat the tests.

B. Gear actuators shall operate valves from fully-open to fully-closed through three cycles without binding or sticking. The pull required to operate handwheel valves shall not exceed 80 pounds. If actuators stick or bind or if pulling forces and torques exceed the values stated previously, repair or replace the actuators and repeat the tests. Operators shall be fully lubricated in accordance with the manufacturer's recommendations prior to operating.

3.07 VALVE CONTROLS

A. Electrically actuated butterfly valve controls shall be programmed so that the closure time from fully open to fully closed is approximately three (3) minutes, minimum, in order to avoid water hammer from sudden valve closure.

END OF SECTION

SECTION 33 14 00

FIELD HYDROSTATIC LEAKAGE TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the cleaning and field hydrostatic leakage testing for above ground steel piping.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Carbon Steel Pipe: 40 20 55.

B. Valves for Water Works: 33 12 16.

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit a hydrostatic leakage testing plan including test blind flange or plug locations, design calculations, filling and draining procedures, and product information for equipment used for testing.

1.04 HYDROSTATIC LEAKAGE TESTING HYDRAULIC GRADE LINE (HGL)

A. The hydrostatic leakage test HGL for all pipes shall be the normal water level of the St. Croix River upstream of the dam = 144.6 ft (NAVD 88).

PART 2 - MATERIALS

2.01 TEST PLUGS

A. If test plugs are used to block the ends of the pipe for the hydrostatic leakage testing, plug must be backpressure rated to accommodate a minimum of 125% of the head differential between the plug location elevation and the test HGL.

B. Test plugs shall be equipped with bypass ports to assist with pipe draining after testing.

2.02 TEST BLIND FLANGES

A. Although end of pipe flanges are not shown on the Drawings, the Contractor has the option to add flanges at the pipe ends in order to attach blind flanges to assist with the hydrostatic leakage testing.

B. Install a 2” (min) outlet on all blind flanges placed on the ends of the pipe to assist with pipe draining after testing. Provide a ball valve on the drain outlet that will be in the closed position during filling and testing.

C. Test blind flanges will be required on the Fish Bypass Pipe manway outlets for hydrostatic leakage testing only. Once testing is complete, manway outlet test blind flanges are to be removed and the FRP outlet flange covers detailed on the Drawings shall be installed. Do not perform leakage testing with the FRP outlet flange covers installed.

D. Test blind flanges shall be designed and fabricated per Section 33 11 11, as applicable.

2.03 TESTING FLUID

A. Water from the St. Croix River.

PART 3 - EXECUTION

3.01 HYDROSTATIC LEAKAGE TESTING PREPARATION

A. Conduct hydrostatic leakage tests on aboveground piping after the piping has been installed and attached to the pipe supports, hangers, anchors, flexible coupling joints, and valves. Where any section of the piping is placed on concrete supports or anchors, do not perform the hydrostatic leakage test until concrete has reached the design compressive strength.

B. Prior to starting the testing, the Contractor shall notify Woodland Pulp and the Engineer.

3.02 CLEANING

A. Before conducting hydrostatic leakage tests, flush pipes with water to remove dirt and debris.

B. Water, sediment, dirt, and foreign material accumulated during this cleaning operation shall be discharged, vacuumed, or otherwise legally removed from the pipe. Coordinate with Woodland Pulp as required.

3.03 INITIAL PIPELINE FILLING FOR HYDROSTATIC TESTING

A. Test plugs, blind flanges or other method for blocking the ends of the pipe (as approved by the Engineer) shall be installed prior to filling.

B. The maximum rate of filling shall not exceed 50 gallons/minute.

C. Butterfly valves on the Attraction Water System pipes shall be in the open position prior to filling.

D. All flume structures upstream of the pipes will need to be filled to achieve the specified test HGL for hydrostatic leakage testing of the pipes.

3.04 HYDROSTATIC LEAKAGE TESTING

A. Butterfly valves on the Attraction Water System pipes shall remain in the open position for the duration of the hydrostatic leakage testing.

B. Subject the piping system to the test HGL for a minimum of 72 hours. The Contractor and Engineer shall then check all joints, fittings, valves, and connections for leaks.

C. The allowable leakage for above ground piping shall be zero (0) gallons. Should leaks be detected, correct leaks and retest until zero leakage is obtained.

D. After a satisfactory test, drain the testing fluid, and remove all test blind flanges or test plugs.

END OF SECTION

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SECTION 35 20 13

WEDGE WIRE SCREEN AND AIR BURST SYSTEM

PART 1 - GENERAL

1.01. SUMMARY

A. Provide banded stainless steel fish screen panels as shown and specified in accordance with the requirements of the Contract Documents and Drawings.

B. Provide a skid-mounted air burst backwash system consisting of compressor(s), receiver, valving, instrumentation and controls necessary to provide sufficient air to backwash intake screen provided as specified herein and as shown on the Drawings. The receiver may be separate depending upon size.

1.02. SUBMITTALS

A. Submit in accordance with Section 01 33 00.

B. Fish Screen Panels:

1. Submit shop drawings, manufacture's data, and literature for the stainless steel screens, supports, and connections.

2. Shop drawings shall include screen dimensions, slot opening, materials of construction and assembly weight.

3. Submit design calculations, by a licensed professional engineer, including loading conditions, support design, and deflection calculations of the stainless steel screen panels.

C. Air Burst System:

1. Submit drawings or literature showing receiver size, piping size, valve literature, compressor manual, electrical schematic, and skid size and weight.

2. Submit design calculations, by a licensed professional engineer, for sizing the compressor, receiver, and piping for the air burst system.

1.03. WARRANTY

A. Wedge Wire Screen

1. Manufacturing Warranty Period: One year from acceptance; furnish Woodland Pulp and Maine DMR items found to be defective within the one year period.

B. Air Burst System

1. Manufacturing Warranty Period: two years from acceptance; furnish Woodland Pulp and Maine DMR items found to be defective within the two year period.

1.04. QUALITY ASSURANCE

A. General

1. All structures and components covered by this Specification shall be designed and constructed in a thorough and workmanlike manner. Due regard shall be given in the design for reliable and safe operation, accessibility, interchangeability, and durability of parts.

B. Wedge Wire Screen

1. Screens shall be manufactured by an ISO 9000 Certified company, fabricated by ASME Section IS Certified welders and the manufacture shall provide evidence of experience in having supplied 5 similar designs which have been in successful service for at least 5 years.

C. Air Burst System

1. Air Burst System shall be supplied by an ISO 9000 Certified company, fabricated by ASME Section IX Certified welders and the manufacturer shall provide evidence of experience in having supplied at least 5 assemblies of similar designs which have been in successful service for at least 3 years.

1.05. DELIVERY STORAGE AND HANDLING:

A. Insofar as practical, factory assemble items specified herein. Package, ship and tag unassembled materials in a manner that will protect materials from damage and will facilitate identification and field assembly.

B. Package stainless steel items in a manner to provide protection from contact with carbon steel.

C. Upon receipt of fabricated assemblies at the job site, the Contractor and the Engineer shall inspect for shipping damage. The Contractor shall replace damaged items at no cost to Maine DMR.

PART 2 - PRODUCTS

2.01. WEDGE WIRE SCREEN

A. Construction: Panel screens shall consist of precision spacing mechanically interlocked profile wire and U-clips with welded frames and supports fabricated from Type 304 stainless steel. The screen surface shall be of smooth profile wire shape with inwardly enlarging opening to minimize the likelihood of debris entrapment. Screen profile wires shall be continuous over the length of each panel as specified herein. Splices are not allowed unless specifically approved by the Engineer. Splices (if approved) shall be smooth and flush and wedge wire screen bars shall be parallel to flow. The wires, U-clips, backing bars and banding shall be welded to form a single unit as shown on the drawings. Welds shall be smooth without burrs or irregularities.

B. Wire and Slot: The surface wire shall be Hendrick Screen Co. No. T16 or approved alternative. The screen slot opening shall be 0.25 inches. The open area for this slot opening shall be 50%. Slot size shall be controlled and continuously monitored during manufacture. The wire orientation shall be parallel to flow.

C. Loading: The screen panels shall be designed for Ultimate load of 6 ft hydraulic differential head and a Working load of 3 ft hydraulic differential head. The maximum deflection from uniform working load shall not exceed ¼ inch. The maximum allowable stress shall not exceed 80% of Yield in any member under Ultimate loads.

D. Tolerances: Screen shall be designed and fabricated so as to ensure that the completed fish panels are within the tolerances specified herein while under a no load condition: The screen panel shall be flat with horizontal to within 0.05 of an inch plus or minus. The diagonal dimensions of the screen panels shall be within 1/8 inch plus or minus. Panel length and width shall be within 1/8 inch plus or minus.

E. Materials and Fittings: The wire and supports shall be 304 stainless steel. The remainder of the assembly shall be manufactured of corrosion resistant metal, AISI type 304 stainless steel.

2.02. AIR BURST SYSTEM

A. Air burst system shall be designed by the fish screen manufacturer. The air burst system shall include the compressor, receiver, air piping, and controls.

B. Compressor: A compressor with sufficient capacity to recharge receiver vessel to the screen manufacture’s recommended air burst operating pressure. A two-year warranty shall be provided on compressor parts. Th compressor shall be equipped with a low oil level switch. The compressor shall operate at 480V, 3 Phase, 60- Hz.

C. Receiver: The receiver shall be provided with pressure gauge, safety valve, and automatic drain assembly. The receiver and outlets shall be sized to the screen manufacturer’s recommended air burst operating pressure.

D. Controls: A control panel shall be provided and pre-wired. Manual controls shall provide push button operation of backwash of each screen(s). A quick safety disconnect shall be provided to terminate power to the compressor(s) and controls. For automatic operation, a timer and/or a PLC shall be provided to control the sequence of operation. A low oil annunciator on the control panel shall be provided. The control panel shall have an auto/off/manual selection switch. The system shall be designed to accept one electrical service hook-up.

PART 3 - EXECUTION

3.01. INSTALLATION

A. The installation of the screen and air burst system shall be in accordance with the project plans and specifications and the manufacturer’s requirements.

B. The wire orientation shall be parallel to flow.

END OF SECTION

SECTION 35 20 16

FABRICATED GATES, GUIDES, AND LIFTS

PART 1 - GENERAL

1.01. DESCRIPTION

A. The work under this section describes the furnishing of gate assemblies and lift mechanisms including their design, manufacture, quality control, shop assembly and testing, delivery, installation supervision, and operational testing. These gates and associated components will serve as the hydraulic control for the Woodland Fish Passage Project.

B. This specification includes gates to be supplied with electric actuators. For additional electric actuator requirements see Specification Section 11 10 00. No part of the gate, gate stem, or lifting yoke can protrude into the water passage opening listed below, unless otherwise noted.

1.02. GATES NOT INCLUDED IN THIS SECTION

A. Fish Lift V-Gate (VG3), see Mechanical Drawings.

B. Fish Lift Hopper Gate (HG5), see Mechanical Drawings.

C. Exit Flume Trap Gates (TG18 & TG19), see Structural Drawings.

1.03. PERFORMANCE REQUIREMENTS AND CHARACTERISTICS

A. Water Passage Dimensions and Elevations at Gate Slots

Gate Number	Gate Name/Location	Opening Width	Gate Height	Sill Elevation	Top Elevation	Discharge
IG1	Fish Lift Isolation Gate	8.0 ft.	12.58 ft.	90.0’	114.58’ (Min)	Upward Opening
EG2	Fish Lift Entrance Gate	8.0 ft.	12.5 ft.	90.0’	98.50’	Downward Opening
IG6	Exit Flume Isolation Gate	8.0 ft.	11.00 ft.	135.4’	157.4’	Upward Opening
IG10	Exit Flume Isolation Gate	6.0 ft	5.1 ft.	141.0’	151.5’	Upward Opening
OWG11	Fish Ladder Automatic Entrance Gate	2.0 ft.	Adjustable	91.6’	97.7’	Downward Opening
IG12	Fish Ladder Isolation Gate	2.0 ft.	11 ft.	91.6’	113.0’	Upward Opening
OWG13	Fish Ladder Automatic Exit Gate	2.0 ft.	Adjustable	138.6’	143.85’	Downward Opening
~~DSG14 (Not in Contract)~~	~~Downstream Bypass Knife Gate~~	~~3.0 ft~~	~~3.0 ft.~~	~~139.5’~~	~~142.5’~~	~~Upward Opening~~
~~DSG15 (Not in Contract)~~	~~Downstream Bypass Knife Gate~~	~~3.0 ft.~~	~~3.0 ft.~~	~~139.5’~~	~~142.5’~~	~~Upward Opening~~
IG16	Downstream Isolation Gate	6.0 ft.	6.75 ft.	139.5’	153.5’	Upward Opening
IG17	Fish Ladder Exit Isolation Gate	2.0 ft.	7.75 ft.	138.6’	154.11’	Upward Opening

B. Dimensions above are the nominal gate opening sizes. Actual gate sizes shall be determined by the Supplier in accommodating guides and seals.

C. Operating Water Elevations. Also refer to Drawings for gate locations and direction of head for gate structural design and actuator sizing.

1. Gate IG1 - Fish Lift Isolation Gate:

   a. Normal Water Level = 96.8’

   b. Max Operating Water Level = 99.7’

2. Gate EG2 – Fish Lift Entrance Gate:

   a. Normal Water Level = 96.8’

   b. Max Operating Water Level = 99.7’

3. Gate IG6 – Exit Flume Isolation Gate:
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’
4. Gate IG10 – Exit Flume Isolation Gate:
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’
5. Gate OWG11 – Fish Ladder Automatic Entrance Gate:
    a. Normal Water Level = 96.8’
    b. Max Operating Water Level = 99.7’
6. Gate IG12 – Fish Ladder Isolation Gate:
    a. Normal Water Level = 96.8’
    b. Max Operating Water Level = 99.7’
7. Gate OWG13 – Fish Ladder Automatic Exit Gate:
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’
8. Gate DSG14 – Downstream Bypass Knife Gate (Not in Contract):
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’
9. Gate DSG15 – Downstream Bypass Knife Gate (Not in Contract):
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’
10. Gate IG16 – Downstream Bypass Isolation Gate:
    a. Normal Water Level = 144.6’
    b. Max Operating Water Level = 145.4’

11. Gate IG17 – Fish Ladder Exit Isolation Gate:

    a. Normal Water Level = 144.6’

    b. Max Operating Water Level = 145.4’

D. Gate speed shall be 10 to 14 inches per minute.

E. Gate IG1 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior tailrace elevation of 99.7 ft. and a dewatered entrance channel (elevation 90 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 9.7 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 8 ft. clear distance to match entrance flume width.

4. The bottom of the gate is to be no less than elevation 102.0 ft. in the raised position.

5. The gate leaf shall have continuous top, bottom, and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

8. The gate shall have a fill gate that shall open with the main operator to reduce the differential head on the gate when the channel is in a dewatered state.

F. Gate EG2 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior tailrace elevation of 99.7 ft.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 3.0 ft.

3. The top of the gate is to be no less than elevation 98.5 ft. in the raised position.

4. The gate leaf shall have continuous side sweeps.

G. Gate IG6 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered entrance channel (elevation 135.4 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 10 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 8 ft. clear distance to match entrance flume width.

4. The bottom of the gate is to be no less than elevation 146.36 ft. in the raised position.

5. The gate leaf shall have continuous bottom and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

H. Gate IG10 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered entrance channel (elevation 141.0 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 4.4 ft.

3. Gate Attachment: Gate guides shall be embedded in the steel gate guide frame shown on the Drawings. The guides shall provide a minimum 6 ft. clear distance to match flume width.

4. The bottom of the gate is to be no less than elevation 146.1 ft. in the raised position.

5. The gate leaf shall have continuous bottom and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

I. Gate OWG11 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior tailrace elevation of 99.7 ft. and a dewatered entrance channel (elevation 91.6 ft.).

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 3.0 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 2 ft. clear distance to match entrance flume width.

4. Gate shall be a three section telescoping leaf gate with fabricated top weir/nose geometry per the Drawings.

5. The top of the gate is to be no less than elevation 97.7 ft. in the raised position.

6. The gate leaf shall have continuous side sweeps.

J. Gate IG12 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior tailrace elevation of 99.7 ft. and a dewatered entrance channel (elevation 91.6 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 8.1 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 2 ft. clear distance to match entrance flume width.

4. The bottom of the gate is to be no less than elevation 102.0 ft. in the raised position.

5. The gate leaf shall have continuous top, bottom, and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

K. Gate OWG13 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered entrance channel (elevation 138.6 ft.).

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 3.0 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 2 ft. clear distance to match entrance flume width.

4. Gate shall be a two section telescoping leaf gate with fabricated top weir/nose geometry per the Drawings.

5. The top of the gate is to be no less than elevation 143.85 ft. in the raised position.

6. The gate leaf shall have continuous side sweeps.

L. Gate DSG14 shall be designed for the following (Not in Contract):

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered pipe (elevation 139.5 ft.).

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 7.5 ft.

M. Gate DSG15 shall be designed for the following (Not in Contract):

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered pipe (elevation 139.5 ft.).

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 7.5 ft.

N. Gate IG16 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered entrance channel (elevation 139.5 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 5.4 ft.

3. Gate Attachment: Gate guides shall be embedded in the steel channel. The guides shall provide a minimum 6 ft. clear distance to match entrance flume width.

4. The bottom of the gate is to be no less than elevation 146.75 ft. in the raised position.

5. The gate leaf shall have continuous bottom and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

O. Gate IG-17 shall be designed for the following:

1. Structural Design Head: The gate shall be designed for a maximum exterior headpond elevation of 145.4 ft. and a dewatered entrance channel (elevation 138.6 ft.). The gate must seal but does not need to be operated under this loading condition.

2. Operating Head: For purposes of sizing the electric actuator, the Design Operating Head shall be 6.8 ft.

3. Gate Attachment: Gate guides shall be embedded in the concrete channel. The guides shall provide a minimum 2 ft. clear distance to match entrance flume width.

4. The bottom of the gate is to be no less than elevation 146.36 ft. in the raised position.

5. The gate leaf shall have continuous bottom and side seals.

6. The gate shall have a positive means of seating (in the closed, full down position) by use of wedges, steel spring leafs or similar method.

7. The seal leakage shall not exceed 0.1 gallons per minute (GPM) per foot of seating perimeter under maximum unbalanced head.

P. There shall be no leaks in the joints between the spliced/welded gate sections.

Q. Gate guides, stems, and fittings shall not project into the water passage, where fish are present, for all gates.

1.04. REFERENCES

The design, fabrication, and installation of the gates, guides, and lifts shall conform, as a minimum, to the practices advocated by the following agencies, professional societies, trade associations, code organizations, and publications:

A. U.S. Army Corps of Engineers (USACE):

1. ETL 1110-2-584 “Design of Hydraulic Steel Structures”

2. EM 1110-2-2610 “Lock and Dam Gate Operating and Control Systems”

3. EM 1110-2-3001 “Planning and Design of Hydroelectric Power Plant Structures”

4. EM 1110-2-3400 “Painting: New Construction and Maintenance”

5. EM 1110-2-4205 “Hydroelectric Power Plants Mechanical Design”

6. CEGS 09900 “Painting, General”

7. CW 09940 “Painting, Hydraulic Structures and Appurtenant Works”

B. American Institute of Steel Construction (AISC)

C. American Welding Society (AWS): AWS D1.1 “Structural Welding Code - Steel”

D. American Society of Mechanical Engineers (ASME)

E. American National Standards Institute (ANSI)

F. American Water Works Association (AWWA): C540 “Electric Actuators for Valves and Slide Gates”

G. American Water Works Association (AWWA): C561 “Fabricated Stainless-Steel Slide Gates”

H. SSPC: The Society of Protective Coatings (SSPC)

I. National Electric Code (NEC)

J. National Electrical Manufacturers Association (NEMA)

K. Occupational Safety and Health Administration (OSHA)

L. American Society for Testing and Materials (ASTM)

M. American Concrete Institute (ACI)

1.05. QUALIFICATIONS

A. The Supplier shall have been in business for at least 5 years, having successfully designed and built several installations of similar scope. At the request of Maine DMR, the Supplier shall submit references and evidence of performance on other projects with similar design conditions.

1.06. QUALITY ASSURANCE

A. All structures and components covered by this Specification shall be designed and constructed in a thorough and workmanlike manner. Due regard shall be given in the design for reliable and safe operation, accessibility, interchangeability, and durability of parts. The Manufacturer shall allow the Engineer, Woodland Pulp, and Maine DMR access to witness shop testing.

1.07. WARRANTY

A. The Supplier shall be responsible for ensuring that the structures and associated equipment supplied form an integral, fully operational and serviceable system. The Supplier shall guarantee all products to be free from defects in material and workmanship for a minimum period of two years from date of acceptance by Woodland Pulp and Maine DMR. The Supplier shall expedite and make all necessary efforts and repairs to correct defects and deficiencies at no expense to Woodland Pulp and Maine DMR.

1.08. SUBMITTALS

A. Proposal shall include the following:

1. Schedule and delivery date(s).

2. Description and drawing(s) of the sealing system(s).

3. Number of sections, per gate, to be assembled onsite.

4. Description of the lifting mechanism(s).

5. Description of controls.

6. The number of days anticipated for onsite supervision for installation, startup, testing and training.

7. Warranty terms.

8. Detailed list of all exceptions taken to this Specification.

9. Recommended spare parts.

10. Alternatives and optional features which may be beneficial to Woodland Pulp and Maine DMR accompanied by associated costs and / or savings.

B. Shop Drawings, catalog cut sheets, and procedures shall be submitted within 90 calendar days of the contract issuance and prior to manufacturing, and shall include the following:

1. Detailed gate drawings (plans, sections, and elevations) showing construction of gates, sealing system, clearances, critical dimensions, tolerances, and storage position.

2. Detailed lifting mechanism drawings (plans, sections, and elevations) showing locations and type of lifting equipment, deck space requirements for lifting equipment, location of control and emergency stop panels, actuator schematics and details.

3. Final calculated reactions to be transferred to the guides and to the superstructure. Load cases include lowering under full head and flow, raising under full unbalanced head, and storage.

4. Design calculations for each gate. Design calculations shall be per USACE ETL 1110-2-584 “Design for Hydraulic Steel Structures”. Design calculations shall be stamped by a Registered Professional Engineer.

5. Blockout and installation details for guide, sill, and header recesses, including tolerances.

6. Painting and coating system information and product data.

7. Unit and shipping weights.

8. Written procedure for shop testing.

9. Written procedure for onsite testing.

10. Component data sheets and cut sheets.

11. Wiring diagrams identifying electrical equipment, internal terminations, and schematic of operation, as well as external instrument, control, and power interconnects. Drawings shall include manufacturer’s name, model number, and ratings.

12. Long term onsite storage requirements.

C. Monthly progress reports with schedule updates shall be submitted beginning at the issuance of the contract and ending at the final acceptance by Woodland Pulp and Maine DMR.

D. Manufacturer’s assembly, installation, maintenance, and troubleshooting instructions to be submitted prior to shipment shall include the following:

1. Record drawings.

2. Shop test results.

3. Installation, operation, and maintenance manuals for all equipment.

4. Name, address, and telephone number of nearest authorized service facilities and parts distributor.

5. List of personnel assigned for onsite assembly, installation, testing, and training. The list shall include the name, title, address, telephone number, and description of duties/expertise of each person.

6. Parts list.

7. Safety procedures.

8. Field test procedures.

E. Inspection and Testing results to be available upon request prior to shipment shall include the following:

1. Manufacturing inspection dates shall be submitted at least 14 calendar days prior to testing to allow the Engineer, Woodland Pulp, and Maine DMR the option for test observations.

2. Certified material test reports and certifications for structural steel, fasteners, welding filler materials, wire rope, forgings, and castings shall be submitted.

3. Welder certifications in accordance with AWS for all welders who performed work on the gate structures and lifting equipment shall be submitted.

F. Shop Drawings and Catalog Cut Sheets Submittal Procedure

1. Initial Submittal: All submittals of Section 1.08 shall be sent to the Engineer for review. Acceptable electronic formats include AutoCAD, PDF, Word, Excel, and MS Project.

2. Returned Submittal: The Engineer shall review and return the Supplier's submittals within 30 calendar days after receipt of such submittals from the Supplier, unless quicker return is requested by the Supplier and agreed to by the Engineer. A copy will be returned with the Engineer's comments and with one of the following notations:

a. No Exceptions Taken

b. Make Corrections Noted

c. Revise and Resubmit

d. Rejected

3. Final Review Copy: When the drawings are returned marked with either (a) or (b), the Supplier is authorized to proceed with the work or purchase of equipment indicated by the returned drawing. Drawings marked (b) shall be corrected and resubmitted within 45 calendar days for record purposes.

4. Re-submittals: When the drawings and/or other submittals are returned marked with either (c) or (d), the Supplier shall revise and/or correct and resubmit the drawings or other material within 45 calendar days after their return to the Supplier. The Supplier shall not begin any work covered by a drawing, data, or sample marked with either (c) or (d) until a revision, correction, or written waiver has been marked with an (a) or (b) by the Engineer and returned to the Supplier.

G. Record Copy Submittal

1. Will encompass record copies of all drawings, product data, manuals, etc. for filing with Woodland Pulp and Maine DMR. This submittal shall be made after completion of the commissioning tests and final acceptance of the equipment by Woodland Pulp and Maine DMR. The closeout submittal shall contain AutoCAD compatible CAD files. For product data, instruction manuals, etc., electronic files in PDF, Word, or Excel format shall be furnished containing original Supplier's literature.

PART 2 - PRODUCTS

2.01. GENERAL

A. Materials

1. Materials used in the fabrication of the gate structures and lifting equipment shall be in conformance with prevailing standards as referenced in Paragraph 1.04References or the manufacturer's standards, whichever results in more durable design. Cast iron is not allowed for any component that is subjected to cyclic stress such as gears, drums, sheaves, and couplings.

B. Design and Fabrication

1. Design and fabrication shall comply with applicable portions of the codes and specifications referenced in Paragraph 1.04 References. Loadings, impact allowances, and allowable stresses shall be in accordance with governing industry standards.

2. Gates and guides shall be supplied as an integral unit to the extent possible. If gate and guide dimensions prohibit supply as an assembly, the gates and guides shall be shop assembled and match-marked prior to shipping.

C. Gates must be lockable for lockout/tagout (LOTO) isolation purposes. Coordinate with Woodland Pulp.

2.02. GATES

A. Materials

1. Gate body, skin plate, and guides shall be at the Suppliers option: painted/coated carbon steel, or stainless steel.

2. Carbon steel plates, angles, and channels shall meet the requirements of ASTM A36. High-strength low-alloy steel wide-flange shapes shall meet the requirements of ASTM A992.

3. Stainless steel shall be Type 304L or 316L.

B. Load and Resistance Factor Design (LRFD) Parameters

1. The gate structure and guides shall be designed using LRFD methods in accordance with USACE ETL 1110-2-584 “Design of Hydraulic Steel Structures”.

2. Include the additional reliability / performance factor α = 0.90 from ETL 1110-2-584, Paragraph 3.1.1.

3. Design per the LRFD load factors, load combinations, and guidelines of ETL 1110-2-584, Appendix E Vertical Lift Gates.

C. Girders shall span horizontally. Vertical framing systems shall not be used.

D. Skin plate deflection shall not exceed 0.4 times the plate thickness.

E. If carbon steel material is used, use continuous welds or seal welds to prevent water penetration into the joints.

F. Exceptions are the bolted joints necessary to assemble the gate sections in the field, if required.

G. Water pondage on or within structural members shall be prevented by design or by the use of drain holes.

H. Design for a minimum expected service life of 50 years.

I. Gate leafs shall be shipped as a single fabrication if at all possible.

2.03. SEALS

A. Molded Rubber Seals

1. Compound shall be natural rubber/polyisoprene.

2. 60 (min) to 70 (max) Shore A, Durometer Hardness.

3. Corner seals and angled seals shall be full-molded.

4. All joints shall be vulcanized at the factory such that the side and bottom seals form one continuous length. No field splicing shall be allowed.

B. Mounting Strips, Clamp Bars, and Seal Strips

1. Type 304 or 316 stainless steel.

2. Surface roughness 125 micro inches.

3. Fastening hardware shall be Type 304N or 316N conforming to ASTM A193 Grades B8N, B8NA, B8MN, or B8MNA.

2.04. GUIDES

A. Supplier shall furnish the following:

1. Blockout details for the vertical guides and sill.

2. Anchor bolts.

3. Threaded rods, turnbuckles, and nuts to align and secure the guides.

4. Guides shall be stainless steel or galvanized steel.

5. Stainless steel shall be Type 304L or 316L.

B. The Supplier shall provide a comprehensive installation procedure for the guides, sills, and headers including alignment tolerances. One of the objectives of the guide installation shall be to produce an alignment where the centerlines of the bearing tracks form the edges of an imaginary plane that is square, vertical, and perpendicular to the direction of flow. The Supplier's tolerances for the installed bearing tracks shall be within the limits described below and shall be achieved by a combination of machining, as appropriate, and field alignment. The Supplier is responsible for assuring that its tolerances and fabrication procedures produce a functioning system of gate, seals, and guides that satisfies the travel and leak requirements described in Paragraph 1.03.

1. Along a line-of-action that is perpendicular with the flow, the surface at the centerline of the bearing track shall not deviate more than +1/16" from the vertical plane.

2. The span between points at the same elevation and on the centerlines of the bearing tracks shall be within a tolerance of +1/8”.

3. Along a horizontal line-of-action that is across the water flow path, surface points along the centerline of the track shall not deviate more than +1/16 from the vertical.

4. The absolute elevations of the sill sealing surface and the top sealing surface shall not deviate more than +1/16” from their respective theoretical elevations.

5. The rate of change of all of the above shall not exceed more than 1/16” along any 20’-0” length.

2.05. ACTUATORS

A. Actuators, lifting, or torque shafts and interconnecting shafts shall be arranged nominally as shown on Drawings. Alternate arrangements may be proposed for review by the Engineer and Woodland Pulp.

B. Lifting equipment shall incorporate motor, integral reversing starter, local control facilities and terminals for remote control, and indication connections housed within a self-contained, sealed enclosure. Except as modified here, actuator design shall be in accordance with AWWA C540 “Electric Actuators for Valves and Slide Gates”.

C. Lifting equipment shall be designed for balanced or unbalanced head and flow conditions as specified in Section 1.03. The entire operating mechanism shall be designed to withstand any shock resulting from operation with improper setting of limit or torque switches or with foreign matter lodged in the gate.

D. All components of gate lifting equipment shall be designed for the maximum normal full load torque of the electric motor, with a minimum factor of safety of five (5.0) based on the ultimate tensile strength of the material. All components shall be designed for a unit stress not to exceed 75 percent of the yield strength of the material, using the locked rotor torque rating of the motor, available through the control system. Components, which may fail in buckling compression, shall be designed for 1.25 times the locked motor thrust, using the Euler or J.B. Johnson formulas, as appropriate. These criteria determine the maximum allowable stresses for all components. Components used as fuses, such as some shear bolts, keys, torque-limiting couplings, etc. shall not be designed to these criteria.

E. The lifting equipment and their supports shall be designed for a seismic acceleration per Specification Section 01 81 10. The member stresses for the seismic condition shall conform to the American Institute of Steel Construction Specification for Structural Steel Buildings.

F. Lifting units shall be o-ring sealed, watertight to IP66/IP68 7m for 72hrs, NEMA 4 or better.

G. Local indicators shall be provided in the form of pilot lights at the local control station to clearly distinguish the fully open and fully closed positions. All gates listed under Section 1.03 of this Specification shall have a Mechanical Dial Position Indicator (MDPI) provided that shows the position of the gate along its entire length of travel.

H. Controls: Local controls shall be provided. They shall include open/stop/close commands and a local/remote selector switch. Each electrical gate actuator shall have a local emergency stop feature.

I. Actuator shall be located, oriented, and configured such that the local controls and hand wheel are readily accessible to personnel. All displays shall be readable between waist and eye level.

J. Protection shall be provided for the motor as follows:

1. Stall - the motor shall be de-energized within 8 seconds in the event of a stall when attempting to unseat a jammed gate.

2. Over temperature - thermostat will cause tripping of the motor. Auto-reset on cooling.

3. Single phasing - lost phase protection.

4. Direction – phase rotation correction.

K. A hand-wheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to electrical operation automatically by starting the motor. The hand-wheel or selection lever shall not move on restoration of motor drive.

2.06. WELDING

A. The edges of the members to be welded shall be sheared, flame-cut or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from slag, rust, grease, and other foreign matter.

B. All welding shall be performed in accordance with applicable piping, structural and welding codes and shall be approved by the Engineer. All welded fabrications shall be designed, fabricated, stress relieved and inspected in accordance with applicable codes.

C. All welders and welding operators assigned to the work shall be certified and experienced on similar projects.

2.07. PAINTING

A. Gates and Guides

1. Carbon steel surfaces shall be prepared in accordance to SSPC SP10 “Near-White Blast Cleaning” after fabrication and just prior to painting.

2. Apply 2 or more coats of N69F Epoxy coating for a minimum dry film thickness of 14 mils.

3. Finish color to be selected by Woodland Pulp from the Supplier’s standard offerings.

4. Paint shall be lead-free, high-solids, low VOC.

5. Submit paint system details for approval by the Engineer.

6. Provide 1 gallon of touch-up paint for each type of paint to match finish and gloss.

B. Lifting Equipment

1. Steel surfaces shall be prepared in accordance to SSPC-SP6 “Commercial Blast Cleaning” after fabrication and just prior to painting.

2. Factory applied primer and paint shall be suitable for long-term outdoor exposure of at least 20 years.

3. Color and surface finish shall be selected by Woodland Pulp from the Supplier’s standard offerings.

4. Paint shall be lead-free, high-solids, low VOC.

5. Submit paint system details for approval by the Engineer.

6. Provide 1 gallon of touch-up paint for each type of paint to match finish and gloss.

C. The following surfaces shall not be painted:

1. Embedment surfaces in contact with concrete.

2. Rail surfaces in contact with wheels.

3. Wheel running surfaces (if any).

4. Stainless steel.

2.08. ELECTRIFICATION

A. Power supply for the lifting mechanisms shall be 480 Volts, 3 Phase, 60 Hertz. All power required for the operation of the lifts shall be developed from a single such branch circuit.

B. For each lifting unit, the Supplier shall provide a non-fused, 480 Volt, 3 phase manual disconnect switch designed and installed in accordance with the requirements of the National Electric Code. Opening of main line manual disconnect shall completely de-energize the lifting unit. The main disconnect switch shall be capable of being padlocked in the “Off” position.

C. Protect and enclose electrical terminations and connections.

D. All enclosures shall be NEMA 4 or better.

E. Ground electric motors and structural frames.

2.09. SAFETY

A. All breakers and valves shall be of a physically lockable design.

B. Install protective guards at all hazardous contact points, pinch points, and moving parts including locations such as the motor drives.

C. Provide an emergency stop pushbutton at each of the lifting units.

2.10. LABELING

A corrosion-resistant metallic nameplate shall be permanently fixed to each gate and to each lifting unit with the following minimum information permanently imprinted into the nameplate:

1. Name of Supplier.

2. Model Number and Serial Number.

3. Date of manufacture (Month and Year).

PART 3 - EXECUTION

3.01. ASSEMBLY, TESTING, AND PREPARATION FOR SHIPPING

A. The Supplier shall provide 14 calendar days advance notice to the Engineer, Woodland Pulp, and Maine DMR prior to shop tests and assemblies to allow the option to witness the shop tests and assembly.

B. The gate sections and seals shall be assembled in the Supplier's plant and the monolithic structure shall be verified to be within the approved tolerances. The gate sections and seals shall be carefully pinned or match-marked, and then disassembled for shipment. Gate sections shall be sized and components shall be assembled to the greatest extent possible for shipping.

C. Prior to shipment, the gates shall be cleaned and all exposed finished parts and electrical equipment protected for shipment. Properly lubricate all gear boxes, bearings, etc. prior to shipment from factory. An extra protective coating shall be applied to allow outdoor storage of structural parts for up to one year prior to installation. Electrical components requiring indoor storage shall be packaged separately and marked for easy identification by onsite personnel.

D. The Engineer and Woodland Pulp shall be given a draft copy of the operation and maintenance instructions before final assembly.

E. The Engineer, Woodland Pulp, and Maine DMR shall be given a final copy of the storage requirement before shipment.

F. No shipment shall be made without final release by Supplier's quality assurance and the acceptance from the Engineer, Woodland Pulp, and Maine DMR.

3.02. SHIPPING, RECEIVING, AND STORAGE

A. Oversized loads may be used to meet the requirements of 2.01; however, the freight cost for oversized loads shall be included by the Supplier in the Contract Price.

B. Deliver embedded parts (guides) prior to gates for ease of construction (if a single assembly cannot be shipped). Coordinate with the Contractor on delivery dates.

C. The equipment shall be unloaded and stored by the Contractor according to the Supplier's specifications prior to installation. Supplier shall furnish long term storage requirements with submittals.

D. No equipment shall be supplied or delivered to the job site until the written approval from the Engineer, Woodland Pulp, and Maine DMR has been obtained by the Supplier.

E. Fourteen (14) calendar days advance notice shall be given by the Supplier to Woodland Pulp of intent to ship any item. The notice shall give expected time of arrival, carrier, quantities, approximate weight, bill of lading number, point of origin, and destination. The Supplier shall specify unloading and storage requirements of the equipment to be delivered.

F. The equipment shall be delivered at the job site only between the hours of 8:00 A.M. and 3:00 P.M. Monday through Friday except on federal or state holidays.

G. Care shall be taken in loading and transporting to prevent damage to the gate sections and appurtenances.

H. All equipment shall be identified with a tag stating the purchase order number, item number, description, job number, and equipment number even if the equipment is crated or boxed. If crated or boxed, the same information shall be placed on the crate or box in letters at least one-inch high.

I. Lifting and support points shall be clearly identified.

J. The Engineer, Woodland Pulp, and Maine DMR shall have the right to inspect in detail all equipment delivered. Any equipment inspected to be defective shall be immediately replaced or repaired by the Supplier. Repairs shall be subject to acceptance by the Engineer, Woodland Pulp, and Maine DMR.

K. The Contractor shall store equipment to permit easy access for inspection and identification. The equipment shall be kept off the ground and protected from corrosion and deterioration.

3.03. INSTALLATION, INSPECTION, OPERATIONAL TESTING, AND TRAINING

A. The Supplier shall furnish competent supervisory installation personnel who shall perform the following services:

1. Provide technical direction for the assembly, alignment, installation, erecting, starting, and operating of the equipment.

2. Inspect embedment placements for conformance with approved shop drawings and contract documents prior to their grouting. Bring nonconforming work to the attention of the Engineer prior to proceeding with the gate installation. Non-conforming assemblies or installations shall be corrected prior to operation and testing.

3. After assembly and installation, the Supplier shall supervise any adjustments, operate and test all gate controls and operations, and supervise the preparation for inspection, testing, and final acceptance by the Engineer, Woodland Pulp, and Maine DMR.

4. Instruct Woodland Pulp's representatives in the operational and maintenance features of the equipment.

B. All Supplier representatives shall read, write, and speak fluent English.

C. The gates and lifting equipment shall be installed in strict conformance with Supplier's drawings and instructions, and inspected by a Supplier's representative. Supplier shall provide all necessary accessories to make the gate systems complete, usable, and capable of meeting the requirements specified in Paragraph 1.03.

D. The Engineer, Woodland Pulp, and Maine DMR shall witness the startup and operational testing of the gates. Supplier shall notify the Owner at least 5business days prior to conducting each operation or testing. Testing shall be conducted in accordance with written procedures developed by the Supplier and shall include as a minimum:

1. Dry environment:

   a. Move the gate from fully open to fully closed in several cycles.

   b. Open the gate from fully closed to cracked open using auxiliary handwheel.

   c. Inspect the gate, guides, seals, and lifting equipment.

2. Water passages full, no flow, balanced head:

   a. Move the gate from fully open to fully closed in several cycles.

   b. Open the gate from fully closed to cracked open using auxiliary handwheel.

   c. Inspect the gate, guides, seals, and lifting equipment.

3. Water passage initially full, no flow:

   a. Lower gate to closed position.

   b. Drain the water passage downstream from gate.

   c. Observe and measure leakage of seals.

   d. Inspect the gate, guides, seals, and lifting equipment.

4. Flow in the water passages with power to gates:

   a. Move the gate from fully open to fully closed.

   b. Drain the water passage downstream from gate.

   c. Observe and measure leakage of seals.

   d. Inspect the gate, guides, seals, and lifting equipment.

E. Within 5 calendar days after startup and testing, the Supplier shall provide a factory trained instructor for one (1) day to familiarize Woodland Pulp's operations and maintenance personnel with the inspection, operation, and maintenance of the gate systems. Woodland Pulp shall advise on the availability of personnel, date, and location for training.

3.04. WORK BY CONTRACTOR

A. Unloading and storing of equipment at the site

B. Construct recesses in the concrete substructure for the installation of the guides, sill, and header.

C. Installation of anchor bolts.

D. Placement, alignment, and grouting of the vertical guides, sill, and header in conformance with tolerances specified by the Supplier. These tolerances shall be within the limits described in Paragraph 2.04.

E. Installation of the lifting equipment and ancillary items under the supervision of the Supplier's onsite personnel.

F. Clean equipment for inspection and installation acceptance under the supervision of Supplier's onsite personnel.

G. Power supply to the 480 Volt, 3 Phase disconnect switch.

H. Prior to and after operational tests, check and adjust lifting equipment including anchor bolts, lubricate components, re-top lubrication reservoirs to the full level, and make necessary repairs to the equipment and structures under the direction of the Supplier's onsite personnel.

3.05. ACCEPTANCE

A. Only a written notice of acceptance from the Engineer, Woodland Pulp, and Maine DMR shall constitute final acceptance of the work.

B. Installation, operation, testing, and final inspection constitute the prerequisites for final acceptance. Final inspection shall be made by representatives from the Supplier, the Engineer, Woodland Pulp, and Maine DMR. This final inspection will result in either a written final acceptance or a written punch-list containing items needing corrections, followed by a re-inspection. Final acceptance does not relieve the Supplier of training requirements.

END OF SECTION

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SECTION 35 20 16

RUBBER SEALS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section describes materials, testing, and installation of rubber seals as specified and as shown on the Contract Drawings.

1.02. REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. D395: Standard Test Methods for Rubber Property—Compression Set

2. D412: Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

3. D2137: Standard Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics

4. D2240: Standard Test Method for Rubber Property - Durometer Hardness

1.03. SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00.

1. Manufacturer's printed data for specified materials and locations where materials are to be used.

2. Submit one physical sample of each type of seal used for the Project.

3. Submit layout drawings for the seals (include seal cross-section dimensions, length of each piece, and identify shop and field splice locations).

1.04. DELIVERY, STORAGE, AND HANDLING

A. Upon receipt of fabricated assemblies at the job site, the Contractor and the Engineer or applicable representative shall inspect for shipping damage. The Contractor shall replace damaged items at no cost to Maine DMR.

B. Store products parts as unstressed as possible for 24 hours at room temperature to reduce distortion.

C. Seals shall be protected from UV exposure.

PART 2 - PRODUCTS

2.01. RUBBER SEALS

A. Seals shall be EPDM rubber by Mi Conveyance Solutions (formerly Seals Unlimited) compound SU66258 or equivalent. The compound shall contain not less than 70% by volume of the basic polymer, and the remainder shall consist of reinforcing carbon black, zinc oxide, accelerators, antioxidants, vulcanizing agents, and plasticizers.

B. Specified rubber seals per the dimensions shown on the Contract Drawings:

1. Hopper gate seal: Mi Conveyance Solutions, J-bulb seal per the dimensions shown in the Contract Drawings.

2. Seal/gasket between steel flume segments: Mi Conveyance Solutions, molded flat seal per the dimensions shown in the Contract Drawings.

3. Seal/expansion joint between steel exit flume and concrete exit flume: Mi Conveyance Solutions, seal molded or extruded to the custom shape shown in the Contract Drawings.

4. Seal/expansion joint between steel exit flume and steel tower: Mi Conveyance Solutions, seal molded or extruded to the custom shape shown in the Contract Drawings.

C. The tensile strength of all shop splices shall be not less than 50 percent of the tensile strength of the unspliced material.

D. Physical characteristics of the seals shall meet the requirements of Table 1.

Table 1 – Rubber Seal Physical Characteristics

Physical Test	**Test Value**	**Test Method Specification**
Tensile Strength	2,000 psi (min.)	ASTM D412
Elongation at Break	400% (min.)	ASTM D412
300 percent Modulus	600 psi (min.)	ASTM D412
Durometer Hardness (Shore Type A)	55 to 65	ASTM D2240
Compression Set	25% (max.)	ASTM D395
Low Temperature Brittleness	Pass with no cracks	ASTM D2137

PART 3 - EXECUTION

3.01. RUBBER SEALS

A. Rubber seals shall be as long as practical to reduce the number of splices. Continuous rubber seals are preferred.

B. Seals shall be accurately fitted and drilled for proper installation.

C. Seals shall be secured in place by bars and fastenings as shown on the Contract Drawings. Fastenings may not be in the zones of seal and seat contact.

D. Seals shall be fitted by the fabricator to the fabricated steel assemblies. The ends of all pieces must be cut at right angles, not beveled. Seals should be cut, and/or dressed, slightly longer than required to permit such fitting without buckling or misalignment. No cement shall be used during such fitting.

E. Splicing

1. Splices shall be completed in the shop as much as practical.

2. Spliced joints should be prepared with a 90-degree cut relative to the cross-section, and buffed square.

3. Splices done in the shop shall be hot vulcanized.

4. Splices done in the field shall be cold vulcanized. An adhesive or caulk should be selected for the appropriate rubber compound being used.

5. Splices shall be completed per the seal manufacturer’s recommendations.

3.02. INSTALLATION

A. Immediately before installing the rubber seals, clean steel surfaces. Install rubber seal per manufacturer's instructions.

3.03. SHOP/FIELD QUALITY CONTROL

A. The Contractor shall notify the Engineer of readiness for items under this Section to be inspected a minimum of 10 working days prior to the items being covered by further work.

END OF SECTION

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SECTION 35 21 00

FABRICATED STOP LOGS

PART 1 - GENERAL

1.01. SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, equipment and incidentals required to install aluminum stop logs, guide frames and stop log lifters as shown on the Contract Drawings and as specified herein.

1.02. REFERENCES

A. American Society for Testing and Materials International (ASTM):

1. A240: Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

2. A276: Standard Specification for Stainless Steel Bars and Shapes.

3. D2000: Standard Classification System for Rubber Products in Automotive Applications.

1.03. SUBMITTALS

A. Provide the following information to confirm compliance with the specification in addition to the submittal requirements specified in Section 01 33 00.

1. Complete description of all materials including the material thickness of all structural components of the stop logs, guide frames, and stop log lifter.

2. Installation drawings showing all details of construction, details required for installation, dimensions, and anchor bolt locations.

3. Maximum bending stress and deflection of the stop logs under the maximum design head.

4. The location of the company headquarters and the location of the principal manufacturing facility. Provide the name of the company that manufactures the equipment if the supplier utilizes an outside source.

1.04. QUALITY ASSURANCE

A. Qualifications

1. All of the equipment specified under this Section shall be furnished by a single manufacturer with a minimum of 5 years' experience designing and manufacturing stop logs. The manufacturer shall have manufactured stop logs for a minimum of 10 projects.

PART 2 - MATERIALS

2.01. GENERAL

A. Stop log assemblies shall be as specified herein and have the characteristics and dimensions shown on the Contract Drawings.

B. Contractor shall field verify existing concrete prior to fabrication of stop log assemblies.

C. Leakage shall not exceed 0.1 gpm/foot of wetted seal perimeter.

D. The stop logs shall be provided with a continuous resilient seal along the bottom and both sides. The guide frames shall not incorporate seals.

E. Stop logs shall be of the height as shown in the Contract Drawings and they shall be designed to function properly when stacked in any order.

F. Stop logs shall be designed to drop into place under their own weight without any downward pressure necessary. Stacking stop plates are not acceptable in lieu of stop logs.

G. All structural components of the stop logs shall be fabricated of aluminum and shall have adequate strength to prevent distortion during normal handling, during installation, and while in service.

H. All structural components of the guide frames shall be fabricated of aluminum or stainless steel and shall have adequate strength to prevent distortion during normal handling, during installation, and while in service.

I. All welds shall be performed by welders with AWS certification.

J. Finish: Mill finish on aluminum and stainless steel. All aluminum in contact with concrete shall be field coated with a heavy coat of bitumastic paint. Welds on aluminum shall be cleaned to provide a uniform finish. Welds on stainless steel shall be sandblasted to remove weld burn and scale.

K. Materials:

Components	Materials
Frame Guides and Invert	Stainless Steel, Type 304L, ASTM A240 or 6061-T6 Aluminum
Stop Logs	6061-T6 Aluminum
Lip Seal	Urethane, EPDM or Neoprene ASTM D2000
Anchor Studs, Fasteners and Nuts	Stainless Steel, Type 316, ASTM A276

2.02. FRAME GUIDES

A. The frame guides or grooves and invert member shall be constructed of stainless steel or extruded aluminum with a minimum thickness of 1/4-inch.

1. Frame design shall allow for surface mounting with stainless steel anchor bolts and grout. Mounting style shall be as shown on the Contract Drawings.

2. An invert member shall be provided across the bottom of the guides. The invert member shall be of the flush-bottom type.

3. Frame mounted seals are not acceptable.

2.03. STOP LOGS

A. The stop logs shall be constructed of extruded aluminum shapes with a minimum thickness of 5/16-inch.

1. Each stop log shall have a maximum height of 12 inches tall unless otherwise indicated on the Contract Drawings.

2. Each stop log shall have a maximum weight of 250 pounds.

3. Maximum bending stress shall not exceed 7,600 psi at the maximum operating head.

4. The stop logs shall not deflect more than 1/360 of the span of the log under the design head shown on the Contract Drawings.

5. Adequate drainage shall be provided for each stop log.

6. Two slots shall be provided in the top of each stop log for removal and installation via the stop log lifter.

7. Each stop log shall be outfitted with an identification tag indicating the manufacturer, width of the opening and maximum head rating at a minimum. Tags shall be welded to each log.

8. Stop logs shall be designed for the differential head stated on the Contract Drawings.

9. The stop logs shall be designed for flow in either direction and seals shall be provided for this condition.

2.04. SEALS

A. Each stop log shall be outfitted with a continuous resilient lip seal along the bottom and both sides to restrict leakage in accordance with the requirements listed in this specification.

1. The continuous lip seal shall be constructed of urethane or rubber and shall be mechanically retained to the stop log.

2. The lip seal shall be activated by a combination of the weight of the stop log and the differential water pressure, which pushes the seal against the inside of the groove assembly.

3. Stop logs that utilize rubber “J” seals or “P” seals are not acceptable.

2.05. LIFTER (LIFTING BEAM)

A. Two (2) stop log lifters shall be provided.

1. The lifter shall be constructed of aluminum and shall be outfitted with UHMW guide bars and stainless steel fasteners.

2. Lifter weight shall be limited to 150 pounds.

3. The lifter shall be provided with lifting hooks designed to engage the slots in the top of the stop logs. A lanyard release will be incorporated into the design.

4. The lifter shall be capable of installing and removing all stop logs of the same width whether they are installed or at the operating floor level.

5. The lifter shall have one large lifting eye centered on lifting beam.

2.06. ANCHOR BOLTS

A. Anchor bolts shall be provided by the stop log manufacturer for mounting the guide frames.

   1. Quantity and location shall be determined by the stop log manufacturer.

   2. If epoxy type anchor bolts are provided, the stop log manufacturer shall provide the studs and nuts.

   3. Anchor bolts shall have a minimum diameter of 1/2-inch.

PART 3 - EXECUTION

3.01. INSTALLATION

A. Installation of the stop logs, guide frames and appurtenances shall be done in a workmanlike manner. It shall be the responsibility of the Contractor to handle, store and install the equipment specified in this Section in strict accordance with the manufacturer's recommendations.

B. The Contractor shall review the installation drawings and installation instruction prior to installing the guide frames.

C. The guide frames shall be installed in a true vertical plane, square and plumb.

D. The Contractor shall fill the void in between the guide frames and the wall with non-shrink grout as shown on the installation drawing and in accordance with the manufacturer's recommendations.

3.02. FIELD TESTING

A. After installation, all stop logs shall be field tested in the presence of Woodland Pulp and the Engineer to ensure that all items of equipment are in full compliance with this Section. The stop logs shall be inserted into the guide frames to confirm that they operate in accordance with the specification. Each stop log assembly shall be water tested by the Contractor, at the discretion of Woodland Pulp and the Engineer, to confirm that leakage does not exceed the specified allowable leakage.

END OF SECTION

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SECTION 40 05 13

STAINLESS STEEL PIPING

PART 1 - GENERAL

1.01 SCOPE:

This Section includes detailed requirements for various stainless steel piping.

1.02 REFERENCES:

A. American Society for Testing and Materials International (ASTM):

1. A194: Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

2. A307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.

3. A312: Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.

4. A403: Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.

1.03 SUBMITTALS:

A. Product Data: Submit for pipe, fittings, flanges, face rings, bolting, and gaskets.

B. Shop Drawings:

1. Shop Drawings showing layout for stainless steel piping. Including dimensions and fittings.

2. Submit in accordance with Section 01 33 00.

1.04 WELDING QUALIFICATIONS:

A. The Contractor shall be responsible for qualifying welders as required by ANSI B31.3 and ASME Boiler and Pressure Vessel Code, Section IX.

B. The Contractor shall maintain record of welding procedures used and welders or welding operators assigned to this Project and their symbols. Records shall show date and results of procedure and performance qualifications.

1.05 DELIVERY, STORAGE, AND HANDLING:

A. Shipping:

1. Sections with field welded ends shall have wooden plug securely installed at each end to prevent pipes from being bent out of round.

2. Flanged connections shall have plywood blind wired over end and through bolt holes to hold flange against face ring.

3. Ship protected from damage and contact with carbon steel.

4. Tarp sections during shipment to avoid contact with road dust and salt spray.

B. Storage: Store protected from damage and contact with carbon steel.

PART 2 - PRODUCTS

2.02 PIPE:

A. 1/2 in. to 6 in.:

1. ASTM A312, Grade TP304L (UNS S30403).

2. Dimensions: Conform to ANSI B36.19.

3. Wall Thickness: Schedule 40.

2.03 FITTINGS:

A. 1/2 in. to 1 in.:

1. ASTM A403, Class WP, Grade 304L.

2. Dimensions: Conform to ANSI B16.11, socketwelded, 3,000 lb pressure class.

B. 1-1/4 in. to 6 in.:

1. ASTM A403, Class WP, Grade 304L.

2. Dimensions: Conform to ANSI B16.9, Buttwelded.

3. Elbows shall be long radius unless otherwise indicated on Drawings.

4. Wall Thickness: Schedule 40.

2.04 JOINTS:

A. Flanged Joints:

1. Size: 1-1/4 in. to 6 in.

2. Flange: Type 304L stainless steel back-up type, faced and drilled to 150 lb class in conformance with ANSI B16.5.

3. Face Ring: Type 304L stainless steel angle ring or flat plate. Flat plate thickness to suit pipe wall thickness and welding procedure to avoid warpage.

4. Bolting: ASTM A307, Grade A, hex head bolts, Class 2A with dimensions in conformance with ANSI B18.2.1, with ASTM A194, Grade 2 or 2H, heavy hex nuts, Class 2B UNC, cadmium plated, with dimensions in conformance with ANSI B18.2.2.

5. Gaskets: Ring-type, PTFE composition, non-asbestos, recommended as suitable for service by gasket manufacturer, similar to Garlock "Gylon" style.

2.05 SHOP FABRICATION:

A. Dimensions:

1. Piping dimensions of fabricated sections shall conform to dimensions for manufactured pipe in ANSI B36.19.

2. For purpose of shop fabrication, dimensions shown on Drawings shall be considered approximate only. Field verification is responsibility of the Contractor. Where possible, use field welds in each direction with adequate allowance for trim and fit, but not less than 2 in. in each direction. Loose flanged shall be provided for fit up at equipment connections.

B. Branch Connections:

1. Nozzle welds may be used in lieu of buttwelded reducing tees when permitted by ANSI B31.3. Buttwelded tees shall be used when branch is same size or 1 pipe size smaller than header. Nozzle welds shall be reinforced in conformance with ANSI B31.3.

2. Threaded or socket welded full couplings may be used for branch connections of 1 in. or smaller pipe size. Coupling shall comply with Paragraph 2.03A of this section.

C. Shop Welded Joints:

1. Preparation: Equipment used in welding preparation shall be covered or faced to prevent mild steel contamination of stainless steel. Items shall be marked “STAINLESS STEEL” and shall be used for no other purpose.

2. Cleaning: Clean metal to be fused of lubricants, grease, paint, filings, and cuttings. Cleaning with alcohol or acetone. Do not use chlorinated solvents.

3. MIG and TIG Welding: Metal Inert Gas (MIG) welding may be used with automatic or semi-automatic machine welding. Tungsten Inert Gas (TIG) welding shall be used for manual welding of pressure joints. Apply shielding gas protection to underside of weld. Filler metal rods shall be AWS A5.9 Type ER308L or ER316L.

4. SMA Welding: Shielded Metal Arc (SMA) welding may be used at noncritical non-pressure connections and for joining stainless to carbon steel. Welding electrodes shall be stored in dry atmosphere to avoid moisture pick-up. Filler metal rods shall be AWS A5.4 Type E308L or E316L.

5. Dissimilar Metals: Do not weld carbon steel directly to stainless steel piping. Weld "poison pads" of equal thickness and same material of pipe to pipe and attach carbon steel to poison pad. SMA welding may be used to attach carbon steel to stainless pad. Filler metal rods shall be AWS A5.4 Type E309, or ASW A5.9 Type ER309 if TIG welding is used.

6. Shielding Gas: Use welding grade argon or helium-argon mixture.

7. Penetration: Buttweld joints shall have 100% penetration.

8. Tack Welding: Make tack welds with same grade of filler metal as finished weld. Tack welds shall be small enough to be absorbed into following weld beads and have slag and oxides removed prior to finishing weld or be completely removed.

9. Weld Finish: Inside of weld shall be smooth and free from projections and depressions. Grind with iron free grinding wheels labeled “STAINLESS STEEL” used for nothing else. Use 160 grit grinding wheels. Remove scale, oxides, and discolorations from pipes and welds. Products and procedures shall be as recommended by manufacturer.

D. Identification: Fabricated pipe sections shall have line and spool number painted on each section. Line and spool numbers shall agree with Shop Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install in accordance with approved submittals and manufacturer's written instructions.

B. Coat threads of all bolts and fasteners with marine grade anti-seize lubricating compound.

3.02 FIELD WELDED JOINTS:

A. Branch Connections:

1. Nozzle welds or socket fittings may be used in lieu of buttwelded reducing tees when permitted by ANSI B31.3. Use buttwelded tees when branch is same size or one pipe size smaller than header. Reinforce nozzle welds in conformance with ANSI B31.3.

2. Threaded or socket full couplings may be used for branch connections of 1 in. or smaller pipe size.

B. Joint Preparation:

1. Equipment used in welding preparation shall be covered or faced to prevent mild steel contamination of stainless steel. Items shall be marked “STAINLESS STEEL” and used for no other purpose.

2. Prepare buttwelded joints in conformance with ANSI A16.25.

3. Cleaning: Clean metal to be fused of lubricants, grease, paint, filings, and cuttings. Cleaning with alcohol or acetone. Do not use chlorinated solvents.

C. Welding:

1. Protect weld area from wind or draft while welding with gas back-up.

2. Preheat weld area if work piece temperature is less than 60ºF.

3. TIG Welding: Use Tungsten Inert Gas (TIG) welding for welding of critical pressure pipe joints. Apply shielding gas protection to underside of weld. Filler metal rods shall be AWS A5.9 Type ER308L or ER316L.

4. SMA Welding: Shielded Metal Arc (SMA) welding may be used at noncritical pressure pipe joints and for joining stainless to carbon steel. Welding electrodes shall be stored in dry atmosphere to avoid moisture pick-up. Filler metal rods shall be AWS A5.4 Type E308L or E316L.

5. Dissimilar Metals: Carbon steel shall not be welded directly to stainless steel piping. Weld "poison pads" of equal thickness and same material of pipe to pipe and attach carbon steel to poison pad. SMA welding may be used to attach carbon steel to stainless pad. Filler metal rods shall be AWS A5.4 Type E309, or ASW A5.9 Type ER309 if TIG welding is used.

6. Shielding Gas: Use welding grade argon or helium-argon mixture.

7. Penetration: Buttweld joints shall have 100% penetration.

8. Tack Welding: Make tack welds with same grade of filler metal as finished weld. Tack welds shall be small enough to be absorbed into following weld beads and have slag and oxides removed prior to finishing weld or be completely removed.

9. Weld Finish: Inside of weld shall be smooth and free from projections and depressions. Grind with iron free grinding wheels labeled “STAINLESS STEEL” used for nothing else. Use 160 grit grinding wheels. Remove scale, oxides, and discolorations from pipes and welds. Products and procedures shall be as recommended by manufacturer.

END OF SECTION

SECTION 40 20 55

CARBON STEEL PIPE

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section includes materials, fabrication, and testing of steel pipe of the sizes and in the locations shown on the Drawings and as specified herein.

1.02. RELATED WORK SPECIFIED ELSEWHERE

A. Painting and Coating: 09 90 00

B. General Piping Components and Requirements: 33 11 00

C. Flexible Pipe Couplings and Expansion Joints: 33 11 02

D. Valves for Water Works: 33 12 16

E. Field Hydrostatic Leakage Testing: 33 14 00

1.03. QUALITY ASSURANCE

A. Unless otherwise stated, the latest edition for any commercial standards and all manufacturing tolerances referenced therein shall apply.

1. References:

a. American Petroleum Institute (API)

(1) API – Specification 5L

b. American Society of Mechanical Engineers (ASME)

(1) ASME Boiler and Pressure Vessel Code

(2) ASME 16.25 – Buttwelding Ends

(3) ASME B16.5 – Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24

(4) ASME B16.47 – Large Diameter Steel Flanges: NPS 26 through NPS 60.

(5) ASME 16.49 – Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems

(6) ASME B16.9 – Factory-Made Wrought Buttwelding Fittings

(7) ASME B31.1 – Power Piping – Code for Pressure Piping

(8) ASME B31.3 – Process Piping – Code for Pressure Piping

(9) ASME B36.10M – Welded and Seamless Wrought Steel Pipe

c. American Society for Testing and Materials (ASTM)

(1) ASTM A36 – Standard Specification for Carbon Structural Steel

(2) ASTM A106 – Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

(3) ASTM A134 – Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over)

(4) ASTM A135 – Standard Specification for Electric-Resistance-Welded Steel Pipe

(5) ASTM A234 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

(6) ASTM A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

(7) ASTM A984 – Standard Specification for Steel Line Pipe, Black, Plain-End, Electric-Resistance-Welded

(8) ASTM E165 – Standard Practice for Liquid Penetrant Testing for General Industry

(9) ASTM E709 – Standard Guide for Magnetic Particle Testing

d. American Welding Society (AWS)

(1) AWS D1.1 - Structural Welding Code – Steel

(2) AWS A5.1 – Carbon Steel Electrodes for Shielded Metal Arc Welding (SMAW)

(3) AWS A5.17 - Carbon Steel Electrodes and Fluxes for Submerged Arc Welding (SAW)

(4) AWS A5.18 – Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding (GMAW)

(5) AWS A5.20 – Carbon Steel Electrodes for Flux Cored Arc Welding (FCAW)

(6) AWS A5.23 – Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding (SAW)

e. American Waterworks Association (AWWA)

(1) AWWA C200 - Steel Water Pipe, 6 Inches and Larger

(2) AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings

f. Pipe Fabrication Institute (PFI)

(1) PFI Standard ES-24.

1.04. QUALIFICATIONS

A. Manufacturers who are fully experienced, reputable, and qualified in the manufacture of the products to be furnished shall furnish all steel pipe and fittings. The pipe and fittings shall be designed, constructed, and installed in accordance with the best practices and methods and shall comply with these Specifications as applicable.

B. Pipe cylinders, coating, and fabrication of specials shall be the product of one manufacturer that has not less than ten (10) years successful experience manufacturing pipe of the particular type and size indicated. The Pipe Manufacturer must have a certified quality assurance program and all manufacturing, coating operations must be performed at one facility. This certified program shall be ISO 9001:2000 or other equivalent nationally recognized program as approved by the Engineer.

C. Personnel performing NDT shall be qualified as an AWS Certified Welding Inspector (CWI or SCWI) or shall hold a current AWS Radiographic Interpreter Certification and meet the personnel requirements of Section V of the ASME Boiler and Pressure Vessel Code (BPVC).

1.05. SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit materials list showing material of pipe and fittings with ASTM reference and grade. Submit manufacturer's certification of compliance with referenced standards, e.g., ASTM A135.

Provide recertification by an independent domestic testing laboratory for materials originating outside of the United States. Show piping service (water, etc.).

C. Submit piping layout drawings showing location and dimensions of pipe and fittings including flanges, equipment, and expansion joints. Label or number (mark) each fitting or piece of pipe and provide the following information for each item:

1. Stations and elevations.

2. Material of construction, with ASTM or API reference and grade.

3. Wall thickness of steel cylinder.

4. Lining thickness.

5. Paint prime coating, where prime coat is required.

6. Coating thickness.

7. Manufacturer's certificates of compliance with referenced pipe standards, e.g., API 5L, ASTM A106, ASTM A135.

8. If applicable, show the weld sizes and dimensions of grooved-end collars, flanges, reinforcing collars, wrapper plates, and crotch plates.

D. With the shop drawings the following shall be submitted:

1. Calculations for pipe design and fittings reinforcement.

2. A listing of welder certifications and qualifications (PQRs/WPQs).

3. Welding procedure specifications (WPS).

4. Information regarding bracing and shipping packaging.

5. Product data for lining and coating.

6. Certified copies of mill test reports.

E. Submit pipe bending method(s), calculations, shop drawings, pipe bending quality control procedures and quality control test reports.

F. Certifications

1. Upon completion of the Project, the Contractor shall furnish a certified affidavit of compliance for all pipe and other products, or materials furnished under this Section of

the Specifications, as specified in applicable ASME, ASTM standards to which the product was manufactured.

1.06. VERIFICATION

A. Inspections

1. All pipe shall be subject to inspection at the place of manufacture.

B. Tests

1. Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the applicable ASTM requirements and applicable coating standards and certified for conformance to same.

2. The Contractor shall perform the required respective testing at no additional cost to Maine DMR. The Engineer shall have the right to witness all testing conducted by the Contractor, provided that the Contractor's schedule is not delayed for the convenience of the Engineer.

C. Welding Requirements

1. All welding procedures used to fabricate pipe shall be qualified under the provision of ASME BPVC Section IX and AWS D1.1. Welding procedures shall be required for, but not limited to, longitudinal and girth welds for pipe cylinders and fittings, and attachment welds for outlets, reinforcing plates, ring flanges, and anchor rings.

D. Welder Qualifications

1. All welding shall be done by skilled welders and welding operators who have had adequate experience in the methods and materials to be used. Welders shall maintain current qualifications under the provisions of ASME BPVC Section IX and AWS D1.1 for the positions in which they are welding. Machines and electrodes like those in the Work shall be used in qualification tests. The Contractor shall furnish all respective material and bear the respective expense of qualifying their welders.

1.07. HANDLING, STORAGE, AND SHIPPING

A. Pipe shall be fully braced to maintain roundness of ±1 percent during shipping and handling.

B. Coated pipe shall be shipped on padded bunks with nylon belt tie-down straps or padded banding located approximately over bracing.

C. Coated pipe shall be stored on padded skids, sand or dirt berms, sandbags, tires, or other suitable means so that coating will not be damaged.

D. Coated pipe shall be handled with wide belt slings or padded forks. Chains, cables, or other equipment likely to cause damage to the pipe or coating shall not be used.

E. Prior to shipment, coated pipe shall be visually inspected for damage to the coating by the following procedure.

1. When visual inspection shows the coating system has sustained physical damage, the area in question may be subjected to electrical holiday and thickness tests.

2. When the area is tested and there is no reduction in coating thickness below the required minimum, then the area shall be noted “OK” and shall be shipped with no patching required.

3. When the damaged area does show damage going completely to the steel from either a visual inspection or a holiday detector, or the area exhibits thickness less than the required minimum, the area shall be repaired at no additional cost to Maine DMR.

1.08. MARKINGS

A. The Contractor shall legibly mark all pipes and specials in accordance with the laying schedule and marking diagram. Each pipe shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation. All special pipe sections and fittings shall be marked at each end with top field centerline.

1.09. SPECIALS

A. A special is defined as any piece of pipe other than a normal full-length straight section. This includes but is not limited to elbows, short pieces, reducers, adapter sections with special ends, sections with outlets, etc.

PART 2 - PRODUCTS

2.01. MATERIALS

A. Steel Pipe and Fittings

1. Steel pipe shall be API 5L, Grade B; ASTM A106, Grade B; ASTM A135, Grade B; ASTM A134; ASTM A984; or AWWA C200. Pipe conforming to ASTM A134 or AWWA C200 shall be made of steel conforming to ASTM A36 or ASTM A572, Grade 42.

2. Pipe shall be standard weight per ASME B36.10M.

3. Minimum Yield Strength: 35,000 psi.

4. Pipe shall be seamless wrought or longitudinally welded with flanged or butt-welded joints as indicated on the Drawings.

5. Pipe is to be furnished with special lengths, field trim pieces, and closure pieces as required by plan and profile for location of elbows, tees, reducers, other in-line fittings, and closures.

6. All interior welds of the fish bypass pipes and viewing tank outlet pipe shall be ground smooth prior to lining the pipe.

7. Pipe Diameter

    a. See Drawings.

8. Wrought Steel Fittings

    a. Wrought steel butt-welded fittings shall comply with ASME B16.9.

    b. Wall thickness shall be standard weight per ASME B36.10M.

    c. Material for carbon steel fittings shall comply with ASTM A234, Grade WPB.

    d. Ends of fittings shall be compatible with the pipe joint for the particular type of pipe to which the steel fittings connect.

9. Mitered Fittings

    a. Unless otherwise shown on the Drawings, all specials and fittings shall comply with AWWA C208 and meet the minimum dimensional requirements of AWWA C208, except that ends of the fittings may be longer.

    b. Pipe material used in fittings shall be of an equivalent material and the same minimum thickness as the pipe to be connected to.

    c. Fittings shall be equal in pressure design strength and shall have linings and coating as specified for the pipe to which it connects.

    d. Fittings shall be equal in pressure class design as the adjoining pipe. Specials and fittings, unless otherwise shown on the Drawings, shall be made of segmental welded sections from hydrostatically tested pipe, with ends compatible with the type of joint or coupling specified for the pipe. All welds made after hydrostatic testing of the straight sections of pipe shall be tested per the requirements of AWWA C200.

e. All butt and fillet welds made after hydrostatic testing of straight pipe shall be magnetic particle examined in accordance with ASTM E709.

f. Acceptance criteria shall be in accordance with ASME BPVC, Section VIII, Division 1, Appendix 6.

10. Expansion Joints

a. Refer to Specification Section 33 11 02.

11. Dismantling Joints

a. Refer to Specification Section 33 11 02.

12. Design Pressure: 50 psi

13. Field Hydrostatic Test HGL

a. See Section 33 14 00.

14. Flanges

a. Flanges shall be in accordance with ASME B16.47 or ASME B16.5 and flat faced.

b. Shop coating shall be continuous to face of the flange. Flange face shall be shop coated with a soluble rust preventive compound.

2.02. BOLTS, NUTS, AND GASKETS FOR FLANGES

A. See Section 33 11 00.

2.03. LININGS AND COATINGS

A. Interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in accordance with Section 09 90 00. All interior welds of the fish bypass pipes and viewing tank outlet pipe shall be ground smooth prior to lining the pipe.

B. The exterior surfaces of all exposed steel pipe, fittings, and specials shall be cleaned and coated in accordance with Section 09 90 00.

C. Flange faces shall be shop-coated with a rust preventive compound. Manufacturers: Houghton Rust-Veto 344, Rust-Oleum R-9, or approved equal.

2.04. FLANGE INSULATION KITS

A. See Section 33 11 10.

PART 3 - EXECUTION

3.01. FABRICATION, ASSEMBLY, AND ERECTION

A. Beveled ends for butt-welding shall conform to ASME B16.25. Remove slag by chipping or grinding. Surfaces shall be clean of paint, oil, rust, scale, slag, and other material detrimental to welding. When welding the reverse side, chip out slag before welding.

B. Fabrication shall comply with ASME B31.3, Chapter V. Welding procedure and performance qualifications shall be in accordance with Section IX, Articles II and III, respectively, of the ASME BPVC.

C. The minimum number of passes for welded joints shall be as follows. Weld shall be full penetration welds:

Steel Cylinder Thickness (in)	Min. Number of Passes for Welds
Less than 0.1875	1
0.1875 to 0.25	2
Greater than 0.25	3

D. Use the shielded metal arc welding (SMAW) submerged arc welding (SAW), gas-shielded flux-cored arc welding (FCAW), or gas-metal arc welding (GMAW) process for shop welding. Use the SMAW process for field welding.

E. Welding preparation shall comply with ASME B31.3, paragraph 328.4. Limitations on imperfections in welds shall conform to the requirements in ASME B31.3, Table 341.3.2 and paragraph 341.4 for visual examination.

F. Identify welds in accordance with ASME B31.3, paragraph 328.5.

G. Clean each layer of deposited weld metal prior to depositing the next layer of weld metal, including the final pass, by a power-driven wire brush.

H. Welding electrodes for carbon steel piping shall comply with AWS A5.1, A5.17, A5.18, A5.20, or A5.23. Carbon steel flux cored wire shall have a maximum boron content of 0.006%.

3.02. SHOP TESTING OF FABRICATED OR WELDED COMPONENTS

A. After completion of fabrication and welding in the shop and prior to the application of any lining or coating, test each component according to the following requirements.

B. Test Method Requirements - Shop:

1. Test each section of steel pipe in the shop by the hydrostatic test method.

2. Test each section of fabricated bend and each fabricated reducer that is fabricated from steel pipe previously tested. Test the mitered joints by the liquid penetrant method and radiographic method.

3. Test each section of pipe with outlets and wyes attached after completion of the shop hydrostatic test as follows:

    a. For d/D greater than 0.30, where d is nominal diameter of the outlet and D is nominal diameter of main pipeline, test section by the hydrostatic method plus soap and compressed air method at the collar.

    b. For d/D less than 0.30, test the collar by the soap and compressed air method.

4. Perform tests of production welds in carbon steel piping in accordance with AWWA C200 for each heat of steel used.

5. A guided-bend test specimen shall be considered as having passed only if no crack or other open defect exceeding 1/8 inch measured in any direction is present in the weld metal or heat affected zone of the base material after the bending. A tension test specimen shall be considered as having passed only if failure occurs in the base metal at a stress in excess of the minimum specified tensile strength.

6. Test outlet reinforcing collars and wrapper plates on each slip-on flange by the soap and compressed air method.

7. Test backgouge and completed weld of manual process groove welds by the liquid penetrant method. Test completed fillet welds by the liquid penetrant method.

8. Perform 100% ultrasonic testing on manual process circumferential welds and welds at collars and risers.

9. Perform radiographic testing on 20% of the circumferential welds of fabricated bends and reducers, including junctions between circumferential and longitudinal welds.

10. Test the longitudinal welds of fabricated steel cylinder that is to be field welded by the magnetic particle test method.

3.03. HYDROSTATIC, RADIOGRAPHIC, ULTRASONIC, SOAP AND COMPRESSED AIR, LIQUID PENETRANT, AND MAGNETIC PARTICLE TEST METHODS

A. Shop Hydrostatic Test:

1. Vent air from the pipe before the test pressure is applied. Hold the test pressure on each section for a sufficient length of time to permit inspection of all joints.

2. The hydrostatic test pressure for fabricated bends and pipes shall be 150 psi.

3. When subjected to the above hydrostatic test pressure, the pipe shall show no leaks, distortion, or other defects. Repair any leaks or other defects that develop during the hydrostatic test by chipping out and rewelding, after which the repaired section shall again be tested until it shows no leaks or other defects.

4. Test Bulkheads: Furnish and attach dished heads and blind flanges for making the hydrostatic tests, and after completion of the tests, remove the heads and properly restore the ends of the sections.

B. Radiographic Test: Make the radiographs in accordance with the requirements of the ASME BPVC, Section VIII, Pressure Vessels. Repair defects in the welds disclosed by the radiographs. Submit all radiographs and the notation of areas for repair to the Engineer for review.

C. Ultrasonic Test: Make the ultrasonic tests in accordance with the requirements of the ASME BPVC, Section VIII, Pressure Vessels. Repair defects in the welds disclosed by ultrasonic testing. Prepare a report of the ultrasonic testing and submit to the Engineer for review.

D. Soap and Compressed Air Test: Use forced compressed air at maximum 40-psi pressure into the joint, and while the joint is under pressure, swab every portion of every welded seam forming a part of the joint with a heavy soap solution or a commercial bubble-producing leak test fluid. Examine for leakage. Repair any defects disclosed by the test by chipping out, rewelding the chipped section, and retesting. Drill and tap the necessary test holes, and plug weld the holes after testing.

E. Liquid Penetrant Test: Conform to the requirements specified in ASTM E165, under Method B, and "Leak Testing." The materials used shall be either water washable or nonflammable. Products: "Spotcheck" by the Magnaflux Corporation or "Met-L-Check Flaw-Findr" by the Met-L-Check Company. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.

F. Magnetic Particle Test: Magnetic particle test shall conform to the requirements specified in ASTM E709, using the dry powder technique. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.

3.04. PIPE BENDING

A. Bend Radius and Angle

1. See Drawings.

B. Bending Methods and Tolerances

1. Bending methods and tolerances in accordance with ASME B16.49, ASME B31.1, ASME B31.3, or PFI Standard ES-24.

3.05. INSTALLATION

A. Provide pipe supports as detailed in the Drawings.

B. Install pipe without springing, forcing, or stressing the pipe or any adjacent connecting piping, valves or equipment. Any damage to the coating shall be repaired to the satisfaction of the Engineer before the pipe is installed.

C. Longitudinally welded steel pipe shall be installed so that the offsetting joints are located at the top of the pipe between 11 o'clock and 1 o'clock.

D. Each length of pipe shall be cleaned out before installation.

E. Flanged Joints

1. Bolt holes of flanges shall straddle the field top centerline of the pipe. Clean flange faces, bolts and nuts by wire brushing just prior to installation to provide good sealing surfaces.

2. Insert the bolts (or studs), lubricate the bolt and finger tighten the nut onto the bolt or stud. Progressively tighten bolts per the required bolting pattern to the appropriate torque value. Retighten bolts after 4-6 hours as gasket relaxes.

3. Execute care when tightening joints to prevent undue strain upon valves and other equipment.

4. If flanges leak under pressure testing, loosen, or remove the nuts and bolts, reset or replace the gasket, reinstall or re-tighten the bolts and nuts, and retest the joints. Joints shall be watertight.

3.06. TESTING OF FIELD FILLET WELDS

A. Field fillet weld joints shall be tested using magnetic particle testing procures and acceptance criteria as stated in AWS D1.1.

B. Fillet Welds on Field Installed Flanges

1. Fillet welds on field installed flanges shall also be tested by drilling and tapping a ¼-inch national pipe thread hole into the spigot of the pipe between the flange fillet welds. Apply approximately 40 psi of air, or other satisfactory gas, into the annular space between the two fillets welds and maintain for a period of 5 minutes.

2. If the pressure remains at 40 psi, the joint is sealed, and the test is considered passed. If the test drops below 40 psi, maintain the pressure at 40 psi for an external source and paint the welds with soap solution. Mark any leaks indicated by the escaping gas bubbles and repair leak indications.

3. After successfully passing the test, close the threaded opening by welding.

3.07. FLANGE ISOLATION KITS

A. See Section 33 11 00.

3.08. REMOVAL OF INTERNAL BRACING

A. Do not remove the stulls placed in steel pipe until the pipe is installed to pipe supports.

3.09. PAINTING AND COATING

A. Coat and line pipe in accordance with Section 09 90 00.

3.10. FIELD QUALITY CONTROL

A. Perform hydrostatic leakage testing in accordance with Section 33 14 00.

B. Provide all necessary piping between the reach being tested and the water supply, together with all required materials and equipment. Provide blind flanges as necessary to isolate and test pipe.

C. Provide field welding quality assurance and inspection in accordance with AWS D1.1.

D. Repair or replace and retest all pipes failing the pressure test.

E. Protect pipes and provide thrust restraint as required to complete test.

F. Provide for proper legal disposal of test water.

END OF SECTION

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SECTION 40 92 10

ELECTRIC ACTUATORS FOR VALVES

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes materials and installation of electric motor actuators for valves.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Painting and Coating: 09 90 00.

B. Valves for Water Works: 33 12 16.

1.03 REFERENCES

A. American Gear Manufacturers Association (AGMA)

B. American Water Works Association (AWWA)

1. C542 – Electric Motor Actuators for Valves and Slide Gates

C. National Electrical Manufacturers Association (NEMA)

1.04 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Submit manufacturer's catalog data showing all motor actuator parts and materials of construction, referenced by AISI, ASTM, SAE, or CDA specification and grade. Show all motor actuator dimensions and weights. Identify each valve and actuator combination by tag number to which the catalog data and detail sheets pertain. Show coatings.

C. Show the maximum torque required to open and close each motor-actuated valve.

D. Submit certified factory performance test records.

E. Submit motor data including nameplate data, insulation type, duty rating, and torque output at duty rating.

F. Submit electrical schematic drawings and wiring diagrams showing physical locations of components.

1.05 LOCK OUT/TAG OUT

A. Actuators must be lockable for lockout/tagout isolation purposes. Coordinate with Woodland Pulp.

1.06 LABELING OF EQUIPMENT

A. Actuators shall be listed and labeled in accordance with Woodland Pulp standards.

PART 2 - MATERIALS

2.01 ACTUATOR IDENTIFICATION

A. Motorized valves are identified on the Drawings.

B. Motor actuators shall have the name of the manufacturer cast or molded onto the actuator body or shown on a permanently attached plate in raised letters.

2.02 ACTUATOR TAGGING

A. Provide identifying tags for electric motor-actuated valves. Show valve actuator tag number, name or designation as shown in the Drawings, and valve size. Attach tags to actuators by means of stainless steel wire.

B. Actuators must be lockable for lockout/tagout (LOTO) isolation purposes. Coordinate with Woodland Pulp.

2.03 ACTUATOR TORQUE REQUIREMENTS

A. The rated output torque of the motor actuator shall be at least 1.5 times the maximum torque required to open or close the valve at any position including seating and unseating conditions when subjected to the most severe operating condition including any mechanical friction and/or other restrictive conditions that are inherent in the valve assembly. Do not include hammer-blow effect in sizing the actuator to comply with this torque requirement. Coordinate with the valve manufacturer to assure that the motor actuator stall torque output does not exceed the torque limits of the valve operating stem or shaft.

B. Maximum torque shall include seating or unseating torque, bearing torque, dynamic torque, and hydrostatic torque. Assume that the differential pressure across the valve is equal to the pressure or head rating of the valve.

C. Assume a maximum pipeline fluid velocity of 16 fps with the valve fully open, unless a higher velocity is specified in the detailed valve specification.

2.04 DESIGN OF ELECTRIC MOTOR ACTUATORS

A. Design Criteria

1. Duty Cycle – 15-minutes.

2. Power Supply – 480 Volt, 60 Hertz, 3-phase.

3. Enclosure – NEMA 4 or better (motor, controls, push buttons).

4. Class 2 Modulating Service per AWWA C542 (100 starts per hour maximum).

a. Size motors for continuous duty; feedback potentiometer and integral electronic positioner/comparator circuit to maintain valve position; 4- to 20-mA d-c input signal to control valve in remote or auto position; auxiliary contact which closes when the local-off-remote switch is in the remote or auto position; valve position transmitter that generates 4- to 20-mA d-c signal proportional to valve position and is capable of driving into loads up to 1,000 ohms at 24-volt dc; valve closes upon loss of control signal.

B. Actuators shall comply with AWWA C542, except as modified herein. Output capacity of motors shall be sufficient to open or close the valve against the maximum differential pressure when the voltage is 10% above or below normal at the specified service conditions. Motors shall have Class F or H insulation system. Provide motor with torque output (at duty rating) that exceeds the requirements of the following paragraphs including safety factor.

C. Design the actuator to move valve from fully open to fully closed in 180 seconds, minimum.

D. Provide a reversing starter, three overloads (one in each ungrounded leg) or two motor thermal cutouts, 120-volt control power transformer, local-off-remote selector switch, stop-open-close push buttons, and open and closed indicator lights. Provide magnetic starters in actuators for open/close operation and solid-state starters in actuators for modulating operation. Provide dry contact for remote indication of the actuator mode of operation. The contact shall be closed when the local-off-remote selector switch is in the remote position and the internal control power exists.

E. Provide a separate (remote) NEMA 4 (or better) enclosure with local/remote selector switch, stop-open-close push buttons, and open and closed indicator lights for motor actuators.

F. Do not use external conduit for wiring any components within the actuator.

G. Gear actuators shall be totally enclosed and factory-grease packed or oil lubricated. The power gearing shall consist of helical gears of heat-treated steel. Worm gears shall be alloy bronze accurately cut with a hobbing machine. Worm shall be hardened steel alloy. Design gears for 24-hour continuous service with an AGMA rating of 1.50.

H. Position switches shall be integrally geared to the actuator and shall be adjustable and capable of actuation at any point between fully opened and fully closed positions. The position switches shall operate while the actuator is either in manual or in motor operation. Provide motor actuators with position switches capable of being separately used to provide remote indication of end of travel in each direction and to stop motion at the end of travel in each direction.

I. Provide two individually adjustable torque switches to protect the valve and motor against overload in the opening and closing directions. To prevent hammering, the torque switch shall not reclose until the valve is made to travel in the opposite direction.

J. Provide a manually operated handwheel that shall not rotate during electrical operation. In the event electrical power is interrupted, handwheel operation shall be activated by a hand lever attached to the mechanism. While the valve is being operated manually, the motor shall not rotate. Upon restoration of electrical power, the handwheel shall automatically disengage. Design the handwheel diameter such that hand operation will not damage the valve. Provide handwheel with arrow indicating open or close rotation.

K. The position switch and torque switch contacts shall be capable of interrupting at least 0.2-ampere inductive load at 125-volt dc or 6-ampere inductive load at 120-volt ac.

L. Provide a lost motion device for open/close operation to permit the motor to reach full speed before the load is applied. Provide lost motion action for manual operation also. Do not provide lost motion device for modulating applications.

M. Provide minimum 10-watt space heater mounted in the actuator housing to prevent condensation and maintain the temperature in the actuator housing 5 degrees above the ambient temperature in the structure. Heater shall be on at all times.

N. Motor shall de-energize in the event of a stall when attempting to unseat a jammed valve.

O. Provide a time delay to prevent instant reversal of the actuator motor.

P. Provide terminal connections for external remote controls fed from an internal 24-volt or 120-volt supply.

Q. Provide two separate 1/2-inch conduit connections for control and power wiring.

R. Electric motor actuators shall be Rotork IQ3. No substitutions.

PART 3 - EXECUTION

3.01 SERVICE CONDITIONS

A. Refer to the Drawings.

3.02 FACTORY PERFORMANCE TESTING OF MOTOR ACTUATOR

A. Test each actuator prior to shipment in accordance with AWWA C542, Section 5.3. The application torque shall be the maximum torque required to open or close the valve at any position including seating and unseating conditions.

3.03 PAINTING AND COATING

A. Coat electric motor actuators in accordance with Section 09 90 00.

B. Coat electric motor actuator the same as the valve to which it is attached.

C. Color of finish coat shall match the color of the valve to which the actuator is attached.

3.04 SHIPMENT, STORAGE, AND TEMPORARY INSTALLATION BEFORE START-UP

A. Prepare equipment for shipment per AWWA C542, Section 6.2 and the following. The preparation shall make the equipment suitable for six (6) months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals.

B. Identify the equipment with item and serial numbers and project equipment tag numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number and project equipment tag numbers of the equipment for which it is intended. In addition, ship crated equipment with duplicate packing lists, one inside and one on the outside of the shipping container.

C. Pack and ship one copy of the manufacturer’s standard installation instructions with the equipment. Provide the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the jobsite and before start-up.

D. Provide flanged openings with metal closures at least 3/16-inch thick, with elastomer gaskets and at least four full-diameter bolts. Provide closures at the place of manufacture prior to shipping. For studded openings, use all the nuts needed for the intended service to secure closures.

E. Provide threaded openings with steel caps or solid-shank steel plugs. Do not use nonmetallic (such as plastic) plugs or caps. Provide caps or plugs at the place of manufacture prior to shipping.

F. Clearly identify lifting points and lifting lugs on the equipment or equipment package. Identify the recommended lifting arrangement on boxed equipment.

G. If actuators are stored or installed outside or in areas subject to temperatures below 40°F or are exposed to the weather prior to permanent installation, provide the manufacturer's recommended procedures for extended storage. Provide temporary covers over the actuator electrical components. Provide temporary conduits, wiring, and electrical supply to space heaters. Exercise each actuator from its fully open to fully closed position at least once every seven days. Inspect electrical contacts before start-up.

3.05 ATTACHING ELECTRIC ACTUATORS

A. The valve manufacturer shall mount the electric motor actuator and accessories on each valve and stroke the valve prior to shipment. Adjust limit switch positions and torque switches.

3.06 FIELD INSTALLATION

A. Install the valve and actuator as indicated in the Drawings in accordance with the manufacturer's instructions. Keep units dry, closed, and sealed to prevent internal moisture damage during construction. Provide additional hangers and supports for actuators which are not mounted vertically over the valve which may impose an eccentric load on the piping system.

3.07 FIELD TESTING OF MOTOR ACTUATORS

A. Test motor actuators as installed by measuring the current drawn (in amperes) by each motor for unseating, seating, and running conditions. The measured current shall not exceed the current measurement recorded during the factory performance test.

B. If the measured current drawn exceeds the above value, provide a larger motor or gear drive or adjust the actuator so that the measured amperage does not exceed the value.

C. Assure that limit switches are placed at their correct settings. Open and close valves twice and assure that limit switches function.

3.08 LABELING

A. Electric actuators shall be listed and labeled in accordance with Woodland Pulp standards.

END OF SECTION

SECTION 41 22 00

HOPPER ELECTRIC WIRE ROPE HOIST

PART 1 - GENERAL

1.01. DESCRIPTION OF WORK

A. Furnish and install a wire rope hoist to raise and lower a large hopper containing water and fish at an upstream fish passage facility at Woodland Pulp. The fish lift hopper is approximately 18 feet long, 14 feet wide and approximately 5 feet high and includes 14 feet long, angled screen (brail) attached to both sides of the box.

B. The hopper will lift fish approximately 64 feet, where they are released into an exit flume leading to the headpond upstream of the dam. The hopper is lifted vertically only (pure vertical lift), with guides at the corners of the hopper preventing horizontal movement. The floor geometry of the hopper varies along both horizontal directions, causing a non-uniform depth of water inside the hopper and an offset centroid. A lifting frame is designed to allow the hopper to be lifted about its centroid when full of water.

C. The hopper design incorporates wheels that will roll against steel guides on the tower when the hopper is raised and lowered, significantly reducing the frictional loads. The hoist will be base mounted atop the new fish lift tower. Design and location of the hoist supports will be adjusted to accommodate the lifting system mounting location as needed.

D. The hoist will also be automated to cycle regularly but will have electrical push button local controls. Limit switches specified herein are to be provided as part of the lifting system to prevent over lifting of the hopper and provide position indication. An adjustable load limit is requested if available, otherwise the hoist shutoff load limit should be indicated with bid information.

1.02. PERFORMANCE REQUIREMENTS AND CHARACTERISTICS

A. The hoist will lift the hopper approximately 64 feet. If standard hoist specifications are within a few feet of the required total height, they should be proposed if they result in cost savings.

B. Hopper hoist shall have a minimum working load of 30 tons.

C. The target lift rate is at least 25 fpm for the hopper, with a soft start and finish. Please advise what standard gearing and lift rates are available for the hopper weight and duty cycle.

D. The hoist shall be a variable-speed (frequency), electric motor-driven, drum type hoist with gear box with horsepower and gear ratio necessary to achieve the target lift speed at the cyclic frequency and hopper weight indicated in the operation conditions above. If this cannot be achieved, with a 60Hp or smaller hoist motor, supplier shall quote a 60Hp motor/VFD and indicate the maximum speed achievable.

E. The VFD shall be sized to match the requirements of the hoist motor.

F. The VFD shall be installed in a dedicated NEMA 4 enclosure to be located in the control building which is environmentally controlled. The drive shall include 24VDC digital inputs for remote control including raise/lower/stop. Digital outputs shall be isolated contacts suitable for use with externally supplied 24VDC control circuits. The drive shall include a 4-20mA input which shall be the VFD's speed set-point. If this external speed set-point is lost (0mA) the VFD shall default to a configurable speed.

G. The VFD shall have a remote human interface module mounted in the door panel of the provided enclosure so that personnel do not have to open the enclosure to configure, operate, or monitor the VFD.

H. The hoist drum drivetrain shall include rotary cam limit switches which can be set to toggle only once through the hopper's normal range of travel. These will be used to detect hopper over-travel in either up or down direction and consequently disable the hoist drive.

I. The hoist drum drivetrain shall include an absolute rotary encoder in addition to whatever rotary encoder is required by the hoist VFD for speed feedback. This additional encoder will be used by the fish lift controller for absolute position sensing. The absolute encoder must track the hoist's (not the hopper's) full range of travel.

J. The hoist shall include a slack rope indication mechanism with a switch for remote indication to the fish lift controller. The same switch (separate pole) shall also disable VFD downward travel.

K. The hoist shall include a hanging, weighted limit switch that shall disable movement in both directions. This shall serve as the final protective limit switch preventing the hoist from lifting the hook into the drum and/or tower structure.

L. The lifting system will operate from May through mid-July. During normal operation, the cycle frequency (one cycle consists of fully raising and lowering the hopper) of the hopper could be as much as six cycles per hour (almost continuously, stopping for a couple of minutes at the top and again at the bottom to discharge and collect fish). The hoist will be atop the lifting tower and exposed to outdoor elements at all times (not covered). Temperatures between 0° and 120° F should be expected. During the off season, the hopper will be raised and dogged in place, and the hoist lowered enough to unload the hoist hook.

1.03. QUALIFICATIONS

A. Supplier shall have been in business for at least 5 years, having successfully designed and built at least 5 installations of similar scope. At the request of Maine DMR, the Supplier shall submit references and evidence of performance on other projects with similar design conditions.

1.04. QUALITY ASSURANCE

A. All structures and components covered by this Specification shall be designed and constructed in a thorough and workmanlike manner. Due regard shall be given in the design for reliable and safe operation, accessibility, interchangeability, and durability of parts.

1.05. WARRANTY

A. The Supplier shall be responsible for ensuring that the structures and associated equipment supplied form an integral, fully operational and serviceable system. The Supplier shall guarantee all products to be free from defects in material and workmanship for a minimum period of 2 years from date of acceptance by the Engineer, Woodland Pulp, and Maine DMR. The Supplier shall expedite and make all necessary efforts and repairs to correct defects and deficiencies at no expense to Maine DMR.

1.06. SUBMITTALS

A. Proposal shall include the following:

1. Price quote for the entire lifting system including supply, delivery, installation support (3 days).
2. Schedule and delivery date(s).
3. A description and/or schematic indicating the conceptual layout of the lifting mechanism.
4. A list of the hoist and rigging equipment they propose to supply as a complete lifting system, specifications of the hoist, including capacity and load limit information.
5. Safety features of the hoist.
6. Mounting information (bolting patterns) and maximum (load limit) forces including the lifting system total weight to be transferred to the lifting tower, to allow final design of structural elements for support and installation.

7. Variable frequency Drive (VFD) cut sheet, installation manual, and programming manual.

8. The number of days anticipated for onsite supervision for installation, startup, testing and training.

9. Warranty terms.

10. Detailed list of all exceptions taken to this Specification and request-for-quote.

11. Recommended spare parts and itemized cost list.

12. Alternatives and optional features which may be beneficial to Woodland Pulp and Maine DMR accompanied by associated costs or savings.

B. Shop Drawings, catalog cut sheets, and procedures shall be submitted prior to manufacturing and shall include the following:

1. Detailed drawings (plans, sections, and elevations) showing construction of hoist, clearances, critical dimensions, tolerances, storage position.

2. Detailed lifting mechanism drawings (plans, sections, and elevations) showing locations and type of lifting equipment, deck space requirements for lifting equipment, location of control and emergency stop panels, actuator schematics and details.

3. Final calculated reactions to be transferred to the hoist tower. Load cases include lifting, lowering, and torque limit.

4. Unit and shipping weights.

5. Written procedure for onsite testing.

6. Component data sheets and cut sheets.

7. Wiring diagrams identifying electrical equipment, internal terminations, and schematic of operation, as well as external instrument, control and power interconnects. Drawings shall include manufacturer's name, model number, and ratings. Drawings shall be supplied in PDF and AutoCAD format.

8. Details of the lifting hook for the Engineer to ensure that the connection on the lifting frame is properly sized.

C. Monthly progress reports with schedule updates shall be submitted beginning at the issuance of the contract and ending at the final acceptance by the Engineer, Woodland Pulp, and Maine DMR.

D. Manufacturer's assembly, installation, maintenance, and troubleshooting instructions to be submitted prior to shipment shall include the following:

1. Record drawings.

2. Shop test results.

3. Installation, operation, and maintenance manuals for all equipment.

4. Name, address, and telephone number of nearest authorized service facilities and parts distributor.

5. List of personnel assigned for onsite assembly, installation, testing, and training. The list shall include the name, title, address, telephone number, and description of duties/expertise of each person.

6. Parts list.

7. Safety procedures.

8. Field test procedures.

9. VFD Parameter settings list and VFD Parameter Backup.

E. Inspection and Testing results to be available upon request prior to shipment shall include the following:

1. Manufacturing inspection dates shall be submitted at least 14 days prior to testing to allow the Engineer, Woodland Pulp, and Maine DMR the option for test observations.

2. Certified material test reports and certifications for structural steel, fasteners, welding filler materials, wire rope, forgings, and castings shall be submitted.

3. Welder certifications in accordance with AWS for all welders who performed work on the lifting equipment shall be submitted.

F. Record Copy Submittal

Encompasses record copies of all drawings, product data, manuals, etc. for filing with Woodland Pulp and Maine DMR. This submittal shall be made after completion of the commissioning tests and final acceptance of the equipment by the Engineer, Woodland Pulp, and Maine DMR. The closeout submittal shall contain AutoCAD compatible CAD files. For product data, instruction manuals, etc., electronic files in PDF, Word, or Excel format shall be furnished containing original Supplier's literature.

G. Shop Drawings and Catalog Cut Sheets Submittal Procedure

1. Initial Submittal: All submittals of Paragraph 1.06 shall be sent to the Engineer for review. Acceptable electronic formats include AutoCAD, PDF, Word, Excel, MS Project, and Primavera.

2. Returned Submittal: The Engineer shall review and return the Supplier's submittals within 30 days after receipt of such submittals from the Supplier, unless quicker return is requested by the Supplier and agreed to by the Engineer. A copy will be returned with the Engineer's comments and with one of the following notations:

    a. No Exceptions Taken

    b. Make Corrections Noted

    c. Revise and Resubmit

    d. Rejected

3. Final Review Copy: When the drawings are returned marked with either (a) or (b), the Supplier is authorized to proceed with the work or purchase of equipment indicated by the returned drawing. Drawings marked (b) shall be corrected and resubmitted within 30 days for record purposes.

4. Re-submittals: When the drawings and/or other submittals are returned marked with either (c) or (d), the Supplier shall revise and/or correct and resubmit the drawings or other material within 15 days after their return to the Supplier. The Supplier shall not begin any work covered by a drawing, data, or sample marked with either (c) or (d) until a revision, correction, or written waiver has been marked with an (a) or (b) by the Engineer and returned to the Supplier.

H. The Supplier shall submit design calculations to the Engineer upon request.

PART 2 - PRODUCTS

2.01. GENERAL

A. Materials

1. Materials used in the fabrication of the lifting equipment shall be in conformance with prevailing standards as referenced in the manufacturer's standards. Cast iron is not allowed for any component that is subjected to cyclic stress such as gears, drums, sheaves, and couplings. All structural bolts shall be new and unused F3125, Grade A325 high-strength bolts minimum.

2. Wide Flange Structural Steel: ASTM A992.

B. Design and Fabrication

1. Loadings, impact allowances, and allowable stresses shall be in accordance with governing industry standards.

2. Hoist shall be supplied as an integral unit to the extent possible. If hoist dimensions prohibit supply as an assembly, the hoist components shall be shop assembled and match-marked prior to shipping.

3. TOLERANCES

a. Guide surface and slide mounting surface straightness:

(1) ± 1/32'' in any 2 ft length

(2) ±1/8" in length or width of hopper

(3) ± 1/8" out of plane over whole fabrication

b. Assembled Hopper:

(1) Width: ±0"-1/4"

(2) Height: ±1/4"

(3) Out of square: ±1/4"

c. Hopper Guides:

(1) Straightness: ±3/16 inch in length, ±1/16 inch in any 2 ft. length

(2) Out of Plane (twist): ±3/16 inch between cross diagonals

2.02. WELDING

A. The edges of the members to be welded shall be sheared, flame-cut or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter.

B. All welding shall be performed in accordance with applicable piping, structural and welding codes and shall be approved by the Engineer. All welded fabrications shall be designed, fabricated, stress relieved and inspected in accordance with applicable codes.

C. All welders and welding operators assigned to the work shall be certified and experienced on similar projects.

D. Use 309L wire for welding stainless to carbon.

2.03. PAINTING

A. Lifting Equipment

1. Steel surfaces shall be prepared in accordance to SSPC-SP6 “Commercial Blast Cleaning” after fabrication and just prior to painting.

2. Factory applied primer and paint shall be suitable for long-term outdoor exposure of at least 20 years.

3. Color and surface finish shall be selected by Woodland Pulp from the Supplier’s standard offerings.

4. Paint shall be lead-free.

5. Provide 1 gallon of touch-up paint to match finish and gloss.

B. The following surfaces shall not be painted:

1. Rail surfaces in contact with wheels.

2. Wheel running surfaces (if any).

3. Stainless steel or aluminum.

2.04. ELECTRIFICATION

A. Power supply for the lifting mechanisms shall be 480 Volts AC, 3 Phase, 3 Wire, 60 Hertz.

B. Hoist Controls shall maintain a minimum short circuit interrupting capacity of 50 kA.

C. VFD shall be supplied to meet IEEE519 standard for Total Harmonic Distortion contribution.

D. Protect and enclose electrical terminations and connections.

E. All enclosures shall be NEMA 4 or better.

F. Ground electric motors and structural frames.

2.05. SAFETY

A. All breakers and valves shall be of a physically lockable design.

B. Install protective guards at all hazardous contact points, pinch points, and moving parts including locations such as the motor drives.

2.06. LABELING

A. A corrosion-resistant metallic nameplate shall be permanently fixed to each gate and to each lifting unit with the following minimum information permanently imprinted into the nameplate:

1. Name of Supplier.

2. Model Number and Serial Number.

3. Date of manufacture (Month and Year).

PART 3 - EXECUTION

3.01. ASSEMBLY, TESTING, AND PREPARATION FOR SHIPPING

A. Supplier shall provide 14 days advance notice to the Engineer prior to shop tests and assemblies to allow the Engineer the option to witness the shop tests and assembly.

B. Prior to shipment, the hoist shall be cleaned and all exposed finished parts and electrical equipment protected for shipment. Properly lubricate all gear boxes, bearings, etc. prior to shipment from factory. An extra protective coating shall be applied to allow outdoor storage of structural parts for up to one year prior to installation. Electrical components requiring indoor storage shall be packaged separately and marked for easy identification by onsite personnel.

C. The Engineer, Woodland Pulp, and Maine DMR shall be given a draft copy of the operation and maintenance instructions before final assembly.

D. The Engineer, Woodland Pulp, and Maine DMR shall be given a final copy of the storage requirement before shipment.

E. No shipment shall be made without final release by Supplier’s quality assurance.

3.02. SHIPPING, RECEIVING, AND STORAGE

A. Delivery of all structures and equipment shall be free on board (FOB) job site.

B. The equipment shall be unloaded and stored by the Contractor according to the Supplier’s specifications prior to installation. Supplier shall furnish long term storage requirements with submittals.

C. No equipment shall be supplied or delivered to the job site until the Engineer, Woodland Pulp, and Maine DMR written approval has been obtained by the Supplier.

D. Fourteen (14) days advance notice shall be given by the Supplier to Woodland Pulp of intent to ship any item. The notice shall give expected time of arrival, carrier, quantities, approximate weight, bill of lading number, point of origin, and destination. The Supplier shall specify unloading and storage requirements of the equipment to be delivered.

E. The equipment shall be delivered at the job site only between the hours of 8:00 A.M. and 3:00 P.M. Monday through Friday except on federal or state holidays.

F. Care shall be taken in loading and transporting to prevent damage to the hoist and appurtenances.

G. All equipment shall be identified with a tag stating the purchase order number, item number, description, job number, and equipment number even if the equipment is crated or boxed. If crated or boxed, the same information shall be placed on the crate or box in letters at least one-inch high.

H. Lifting and support points shall be clearly identified.

I. The Engineer, Woodland Pulp, and Maine DMR shall have the right to inspect in detail all equipment delivered. Any equipment inspected by the Engineer, Woodland Pulp, and Maine DMR to be defective shall be immediately replaced or repaired by the Supplier. Repairs shall be subject to acceptance by the Engineer, Woodland Pulp, and Maine DMR.

J. The Contractor shall store equipment to permit easy access for inspection and identification. The equipment shall be kept off the ground and protected from corrosion and deterioration.

3.03. INSTALLATION, INSPECTION, OPERATIONAL TESTING, AND TRAINING

A. The Supplier shall furnish competent supervisory installation personnel who shall perform the following services:

1. Provide technical direction for the assembly, alignment, installation, erecting, starting, and operating of the equipment.

2. Inspect placements for conformance with approved shop drawings and contract documents. Bring nonconforming work to the attention of the Engineer prior to proceeding with installation. Non-conforming assemblies or installations shall be corrected prior to operation and testing.

3. After assembly and installation, the Supplier shall supervise any adjustments, operate and test all hoist controls and operations, and supervise the preparation for inspection, testing, and final acceptance by the Engineer, Woodland Pulp, and Maine DMR.

4. Instruct Woodland Pulp's representatives in the operational and maintenance features of the equipment.

B. All Supplier representatives shall read, write, and speak fluent English.

C. The hoist equipment shall be installed in strict conformance with Supplier's drawings and instructions, and inspected by a Supplier's representative. Supplier shall provide all necessary accessories to make the systems complete, usable, and capable of meeting the requirements specified in Paragraph 1.02.

D. After startup and testing, the Supplier shall provide a factory trained instructor for one (1) day to familiarize Woodland Pulp's operations and maintenance personnel with the inspection, operation, and maintenance of the hoist systems. Woodland Pulp shall advise the availability of personnel, date, and location for training.

3.04. WORK BY CONTRACTOR

A. Unloading and storing of equipment at the site.

B. Placement, alignment, and securing of hoist and appurtenances in conformance with tolerances specified by the Supplier. These tolerances shall be within the limits described in Paragraph 2.01.

C. Installation of the hoist equipment and ancillary items under the supervision of the Supplier's onsite personnel.

D. Clean equipment for inspection and installation acceptance by the Engineer, Woodland Pulp, and Maine DMR under the supervision of Supplier's onsite personnel.

E. Power supply to the 480 Volt, 3 Phase disconnect switch.

F. Additional controls and wiring to hoist control PLC.

G. Prior to and after operational tests, check and adjust hoist equipment including, lubricate components, re-top lubrication reservoirs to the full level, and make necessary repairs to the equipment and structures under the direction of the Supplier's onsite personnel.

3.05. ACCEPTANCE

A. Only a written notice of acceptance from the Engineer, Woodland Pulp, and Maine DMR shall constitute final acceptance of the work.

B. Installation, operation, testing, and final inspection constitute the prerequisites for final acceptance. Final inspection shall be made by representatives from the Supplier, the Engineer, Woodland Pulp, and Maine DMR. This final inspection will result in either a written final acceptance or a written punch-list containing items needing corrections, followed by a re-inspection. Final acceptance by the Engineer, Woodland Pulp, and Maine DMR does not relieve the Supplier of training requirements.

PART 4 - SUPPLIERS

4.01. ACCEPTABLE SUPPLIERS:

A. Wisconsin Lifting Specialists
2013 South 37th Street
Milwaukee, WI 53215
(715) 298-9601
https://wisconsinlifting.com/

B. Somatex, Inc.
P.O. Box 487
Pittsfield, ME 04967
(207) 487-6141
https://www.somatexinc.com/

C. New England Crane
70 Commercial Street
Lewiston, ME 04240
(888) 450-0477
https://www.newenglandcrane.com/ne/

D. Konecranes, Inc.
Americas Headquarters
4401 Gateway Blvd
Springfield, OH 45502
(937) 525-5533
https://www.konecranes.com/en-us

END OF SECTION

Supplement A

Survey Information

Survey Drawing List

1. Topographic & Bathymetric Survey Depicting Portions of the Dam and Mill Yard at Woodland Pulp Mill on the Saint Croix River Sheet 1 of 1
2. Topographic Survey Depicting Portions of the Dam and Mill Yard at Woodland Pulp Mill on the Saint Croix River Sheet 1 of 4
3. Topographic Survey Depicting Portions of the Dam and Mill Yard at Woodland Pulp Mill on the Saint Croix River Sheet 2 of 4
4. Topographic Survey Depicting Portions of the Dam and Mill Yard at Woodland Pulp Mill on the Saint Croix River Sheet 3 of 4
5. Topographic Survey Depicting Portions of the Dam and Mill Yard at Woodland Pulp Mill on the Saint Croix River Sheet 4 of 4

DWG files are available on request.

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NOTES

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(2) ELEVATIONS REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) MODELED USING GEOID 18. ELEVATIONS WERE ESTABLISHED ON SITE UTILIZING A TRIMBLE R12I RTK GPS RECEIVING REAL TIME CORRECTIONS FROM THE MAINE DEPARTMENT OF TRANSPORTATION CORS NETWORK.

(3) FIELD LOCATION WAS COMPLETED USING A COMBINATION OF TRIMBLE ROBOTIC TOTAL STATIONS AND TRIMBLE R12 AND R12i RTK SYSTEMS. FIELD LOCATION FOR THIS SURVEY WAS ON JULY 6, 2023; APRIL 25, 2024; MAY 25, 2024; AND SEPTEMBER 6, 2024. THE SITE WAS FLOWN WITH A WISPR RANGER DRONE CARRYING A RESEPI HESAI-PANDARXT LIDAR SENSOR AND A DJI MAVIC 3E PHOTO DRONE ON AUGUST 16, 2024. BATHYMETRIC DATA WAS COLLECTED UTILIZING A SEAFLOOR SYSTEMS HYDROLITE PLUS SINGLE FREQUENCY SONAR UNIT PAIRED WITH A TRIMBLE R12i RTK ROVER. THE WATER LINE DEPICTED WAS DERIVED BY A COMBINATION OF FIELD LOCATION AND PORTIONS WERE DIGITIZED FROM THE ORTHOPHOTO MOSAIC PRODUCED FROM THE PHOTO DRONE IMAGES. PORTIONS OF THE RIVER BED WERE NOT MAPPED FOR THIS SURVEY AS THEY COULD NOT BE SAFELY ACCESSED BY FIELD PERSONNEL.

(4) UTILITY INFORMATION: THE LOCATION SHOWN ON THIS PLAN FOR ABOVE AND UNDERGROUND UTILITIES, INCLUDING BUT NOT LIMITED TO WATER, ELECTRICITY, AND SEWER ARE APPROXIMATE AND SHOULD BE VERIFIED BEFORE ANY EXCAVATION. FEDERAL AND STATE LAWS REQUIRE ANYONE PERFORMING ANY SORT OF EXCAVATION, INCLUDING DIGGING, BORING, BACKFILLING OR GRADING TO NOTIFY "DIG SAFE (1-888-344-7233) AT LEAST 72 HOURS BEFORE THEY BEGIN WORK. THE UNDERGROUND UTILTIES SHOWN HAVE BEEN LOCATED BASED ON UTILITY PAINT MARKS FOUND AT THE SITE. PLISGA & DAY LAND SURVEYORS (PLISGA & DAY) MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. PLISGA & DAY FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATED INDICATED. PLISGA & DAY HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

LEGEND

- ∅ UTILITY POLE
- + UTILITY POLE ANCHOR
- SIGN
- TEMPORARY BENCHMARK (TBM)
- 1' CONTOUR
- 5' INDEX CONTOUR
- EDGE OF GRAVEL
- EDGE OF PAVEMENT
- EDGE OF CONCRETE
- OVERHEAD UTILITY WIRES
- GR GR GR GR GUARD RAIL
- TREE LINE
- CHAIN LINK FENCE

PLISGA & DAY
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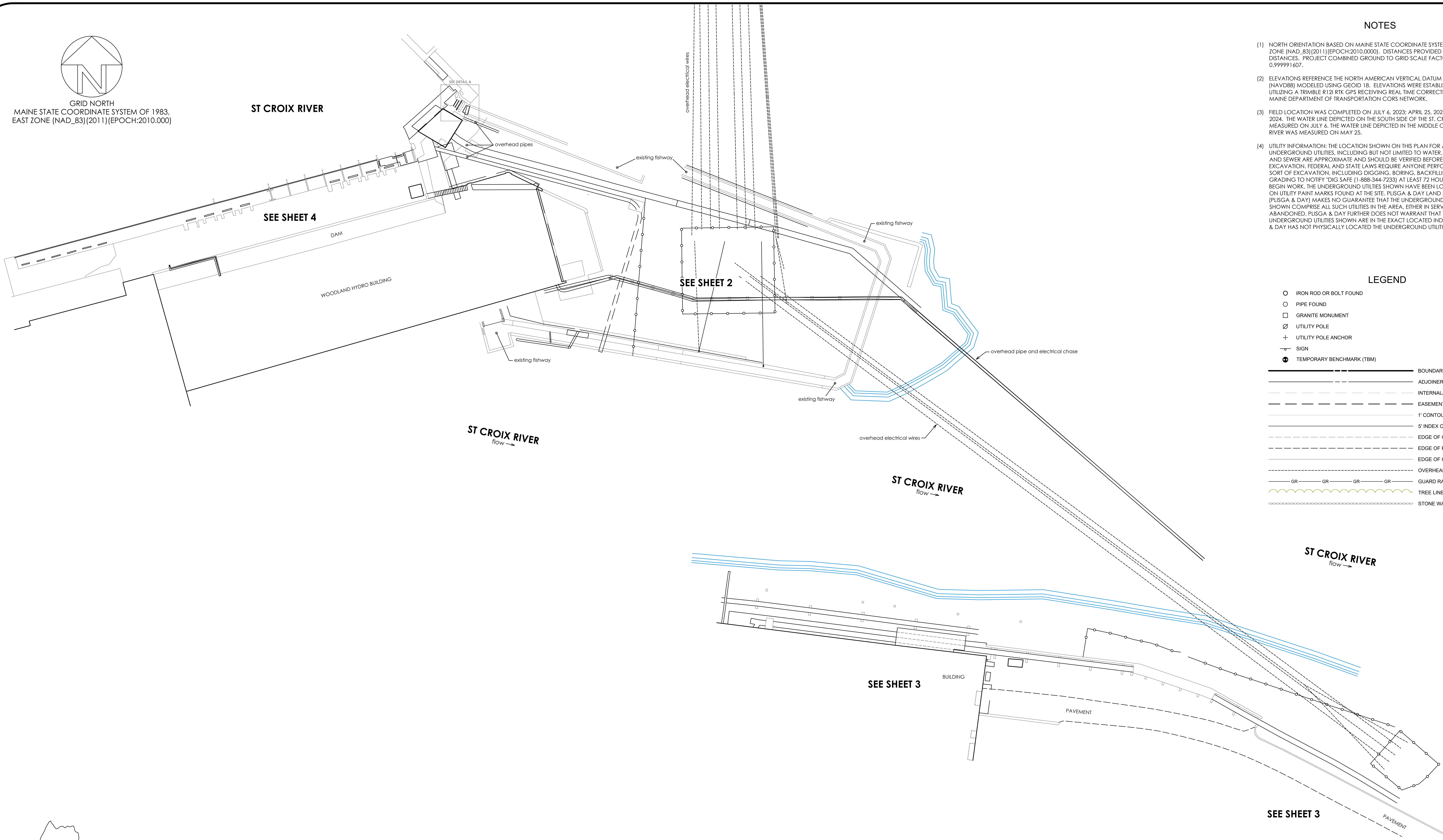
TOPOGRAPHIC & BATHYMETRIC SURVEY
DEPICTING PORTIONS OF THE DAM AND MILL YARD AT
WOODLAND PULP MILL
ON THE
SAINT CROIX RIVER

WOODLAND, BAILEYVILLE
WASHINGTON COUNTY, MAINE

FOR
ALDEN RESEARCH LABORATORY, INC.

SHEET 1 OF 1



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(3) FIELD LOCATION WAS COMPLETED ON JULY 6, 2023; APRIL 25, 2024; AND MAY 25, 2024. THE WATER LINE DEPICTED ON THE SOUTH SIDE OF THE ST. CROIX RIVER WAS MEASURED ON JULY 6. THE WATER LINE DEPICTED IN THE MIDDLE OF THE ST. CROIX RIVER WAS MEASURED ON MAY 25.

(4) UTILITY INFORMATION: THE LOCATION SHOWN ON THIS PLAN FOR ABOVE AND UNDERGROUND UTILITIES, INCLUDING BUT NOT LIMITED TO WATER, ELECTRICITY, AND SEWER ARE APPROXIMATE AND SHOULD BE VERIFIED BEFORE ANY EXCAVATION. FEDERAL AND STATE LAWS REQUIRE ANYONE PERFORMING ANY SORT OF EXCAVATION, INCLUDING DIGGING, BORING, BACKFILLING OR GRADING TO NOTIFY "DIG SAFE (1-888-344-7233) AT LEAST 72 HOURS BEFORE THEY BEGIN WORK. THE UNDERGROUND UTILTIES SHOWN HAVE BEEN LOCATED BASED ON UTILITY PAINT MARKS FOUND AT THE SITE. PLISGA & DAY LAND SURVEYORS (PLISGA & DAY) MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. PLISGA & DAY FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATED INDICATED. PLISGA & DAY HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

LEGEND

- IRON ROD OR BOLT FOUND
- PIPE FOUND
- GRANITE MONUMENT
- UTILITY POLE
- UTILITY POLE ANCHOR
- SIGN
- TEMPORARY BENCHMARK (TBM)
- BOUNDARY LINE
- ADJOINER BOUNDARY LINE
- INTERNAL/TIE LINE
- EASEMENT LINE
- 1' CONTOUR
- 5' INDEX CONTOUR
- EDGE OF GRAVEL
- EDGE OF PAVEMENT
- EDGE OF CONCRETE
- OVERHEAD UTILITY WIRES
- GR GR GR GR GUARD RAIL
- TREE LINE
- STONE WALL

SCALE: 1"= 25'

25' 0 25' 50' 75' 100'

COMBINED SCALE FACTOR: 0.999991607

PLISGA & DAY
LAND SURVEYORS
72 MAIN STREET
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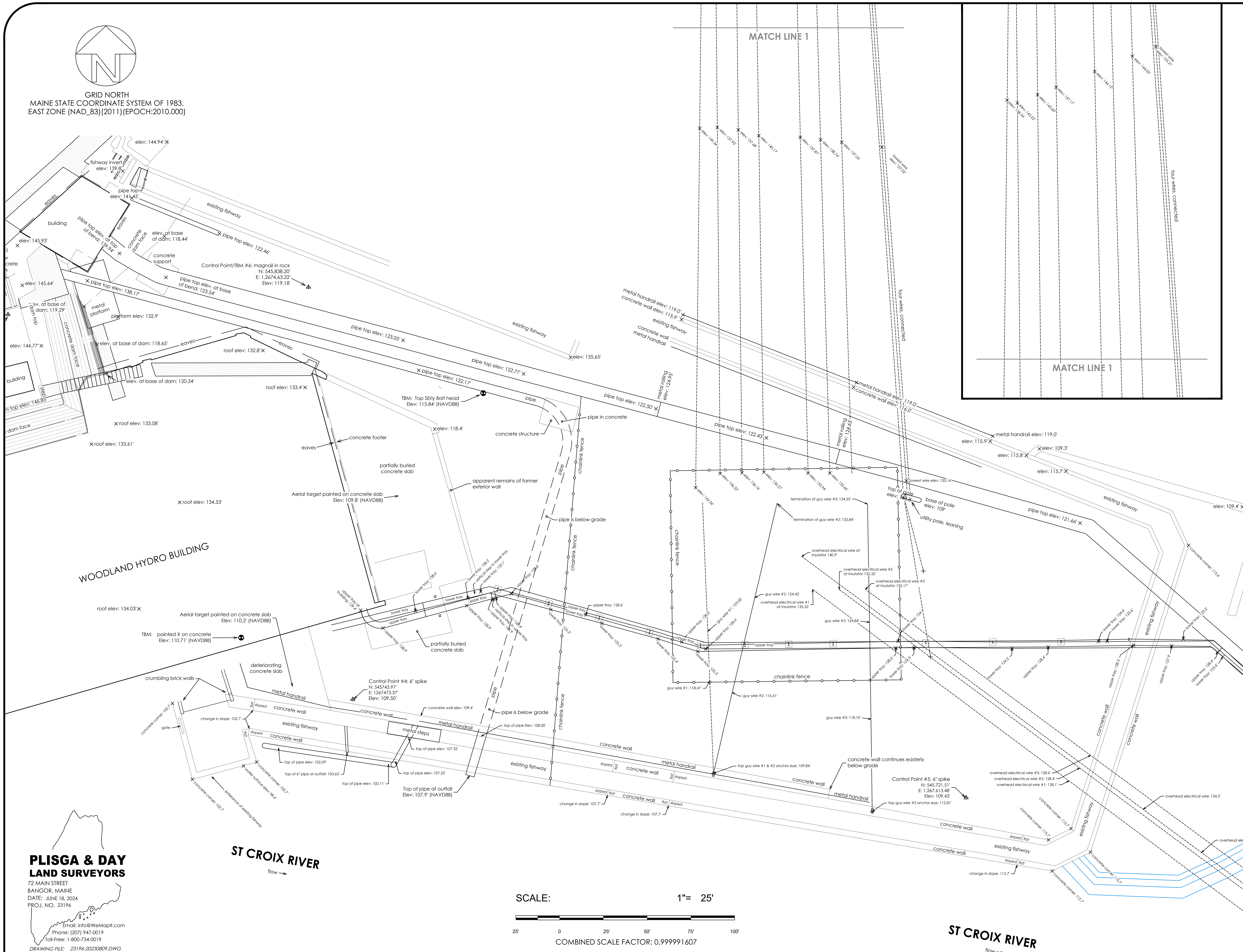
DRAWING FILE: 23196-20230809.DWG
www.WeMapIt.com

TOPOGRAPHIC SURVEY
DEPICTING PORTIONS OF THE DAM AND MILL YARD AT
WOODLAND PULP MILL
ON THE
SAINT CROIX RIVER

WOODLAND, BAILEYVILLE
WASHINGTON COUNTY, MAINE

FOR
ALDEN RESEARCH LABORATORY, INC.



LEGEND

- ¾" REBAR TO BE SET CAPPED "PLISGA & DAY PLS 2537"
- IRON ROD OR BOLT FOUND
- PIPE FOUND
- GRANITE MONUMENT
- GRADE STAKE
- STONE PILE/CAIRN
- UTILITY POLE
- UTILITY ANCHOR
- CONIFEROUS TREE
- DECIDUOUS TREE
- HYDRANT
- TBM: VERTICAL BENCHMARK
- DRILLED WELL
- UNDERGROUND UTILITY BOX
- DUMPSTER
- FLAG POLE
- CATCH BASIN
- SIGN
- WATER UTILITY GATE/SHUT OFF
- WV WATER UTILITY VALVE
- SEWER MAINTENANCE HOLE
- ROCK
- METAL GRATING
- EDGE OF PAVEMENT
- EDGE OF GRAVEL
- EDGE OF CONCRETE
- 1' CONTOUR
- 5' INDEX CONTOUR
- OVERHEAD UTILITY WIRES
- SD STORM SEWER
- S SANITARY SEWER
- W UNDERGROUND WATER UTILITY LINE
- BUILDING
- CHAINLINK FENCE

NOTES

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DEPICTING PORTIONS OF THE DAM AND MILL YARD AT
WOODLAND PULP MILL
ON THE
SAINT CROIX RIVER

WOODLAND, BAILEYVILLE
WASHING COUNTY, MAINE

FOR
ALDEN RESEARCH LABORATORY, INC.

SHEET 2 OF 4

PLISGA & DAY
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SCALE: 1"= 25'

25' 0 25' 50' 75' 100'

COMBINED SCALE FACTOR: 0.999991607

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WOODLAND, BAILEYVILLE
WASHING COUNTY, MAINE

FOR
ALDEN RESEARCH LABORATORY, INC.

SHEET 3 OF 4

LEGEND

- CONTROL POINT
- TEMPORARY BENCHMARK (TBM)
- SPOT ELEVATION
- DOOR AT SILL ELEVATION
- METAL GRATING
- 1' CONTOUR
- 5' INDEX CONTOUR
- EDGE OF CONCRETE
- OVERHEAD UTILITY WIRES
- FENCE

NOTES

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WASHING COUNTY, MAINE

FOR
ALDEN RESEARCH LABORATORY, INC.

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verdantas

Geotechnical Engineering Report

Woodland Fish Lift Passage Design

Prepared for:
Maine Department of Marine Resources

Prepared by:
Verdantas LLC
186 Granite Street
Manchester, NH 03101
603-314-0820

Verdantas Project No: 16667

Revision 1

December 20, 2024

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Table of Contents

Figures

Appendices

1.0 INTRODUCTION

Alden Research Laboratory, LLC (Alden), a Verdantas company, prepared this report to present the results of the geotechnical engineering assessment to support the design of upstream fish passage facilities at the Woodland Dam on the St. Croix River (the Site). This work was performed under advantage contract #13A 20220801000000000335 with the Maine Department of Marine Resources (MDMR) dated August 8, 2023. Included herein is our assessment of subsurface conditions as they relate to the planned design and construction of the fish passage and associated infrastructure. This report is subject to the Limitations included herein.

1.1 PROJECT INFORMATION

Our understanding of the project is based upon our Site observations, geotechnical data collected, review of readily available on-line mapping resources, and on-site conversations with Woodland Pulp and Paper personnel.

The proposed fish lift and associated design components will be built in and along the water's edge, on the island located north of the Woodland Dam tail race and south of the St. Croix River. The project will allow for the upstream and downstream travel of fish, around the existing Dam, and the geotechnical recommendations provided herein are intended to support the proposed design given the physical and geotechnical site constraints. For the purposes of this report, the project in broken into five (5) main design components. These design components are described in the following sections.

1.1.1 Fish Lift

The proposed fish lift is an approximately 140-foot-long by 40-foot-wide structure located on the northern bank of the Woodland Dam tail race. The structure is anticipated to utilize a shallow foundation bearing directly on rock within the river. We understand that the existing retaining wall at the northern end of the tail race will is to be maintained, and the area immediately south of the wall, adjacent to and within the river, will be excavated to design elevations for the fish lift.

1.1.2 Exit Flume

The exit flume is located immediately north of the fish lift and is understood to consist of approximately 200-feet of aboveground flume that will allow for the transport of fish from the lift to the upstream waters above the dam. The exit flume is anticipated to utilize deep foundation systems that extend into bedrock.

1.1.3 Fish Ladder

The fish ladder structure spans approximately 400-feet and consists of a series of weirs and pools that connect the upstream and downstream waters. The structure is located along the southern bank of the St. Croix River. It is currently anticipated that the western portion of the structure, which is higher in elevation, will be elevated on piers supported by spread footings on bedrock, and the eastern portion of the structure, lower in elevation, will utilize a shallow foundation system that bears directly on rock.

1.1.4 Access Bridge

We understand that, currently, the Project Site can only be accessed through the Woodland Dam electric generation facility, which has access-size restrictions. Therefore, a new bridge is proposed to provide more direct and significantly improved access. The access bridge would connect the island's eastern tip to the southern mainland, crossing above the Dam's tail race. The bridge span is approximately 227.5-feet and will utilize a shallow foundation system that bears directly on rock.

1.1.5 Pipe Supports and Access Road Approach

Additional load bearing infrastructure associated with the Project include pipe supports for ancillary piping just outside of the fish lift footprint (to the north), and an elevated access road approach along the southern abutment approach. Both are anticipated to utilize shallow foundation systems that bear on native soil or improved existing fill.

Recommendations for each design component are discussed in **Section 4.0.**

2.0 SUBSURFACE EXPLORATION PROGRAM

2.1 Previous Investigations

Georgia Pacific Corporation, 1984

Georgia Pacific Corporation (GPC) conducted a structural evaluation in 1984 to assess the existing structural integrity and subsurface conditions along the Woodland Dam hydraulic wall. The investigation focused on the hydraulic wall located on the western side of the hydro power plant. Of interest from this investigation's findings is that bedrock was classified as relatively dense, metamorphic rock, with laboratory testing calculating the rock density to be 175 pcf. Overburden fill material noted the presence of construction rubble, which may be indicative of construction filling practices at the facility.

AMEC Environnent and Infrastructure, Inc. 2014/2015

AMEC Environnent and Infrastructure, Inc. (AMEC) conducted a geotechnical investigation in 2014 and 2015 to support the proposed construction of a new Tissue Machine Building. The investigation took place on the western side of the mill property, opposite the river. Of interest from this investigation is that the bedrock quality generally improves with depth (as shown by the RQD values).

2.2 Verdantas Ground Penetrating Radar Survey

Private utility clearance services were provided at locations on the island and mainland by Ground Penetrating Radar Systems, LLC (GPRS) on September 27, 2023. Verdantas provided oversight of the work performed by GPRS.

GPRS surveyed a 10-foot radius around proposed boring locations related to exploration activities described in Section 2.3. The proposed B-7 location could not be scanned due to restricted access. The effective survey detection depth was reported to be approximately 2 to 3 feet below the ground surface. GPRS utilized GPR as well as "radio" and "power" modes with an electromagnetic locator. Unknown pipes were located in proximity to B-1. Two catch basins filled with soil, and one filled with water were located, but the orientation of the associated pipe network could not be identified. Identified obstructions were marked using spray paint and flags. A copy of the GPRS report is included as Appendix B.

2.3 Verdantas Investigation, 2023/2024

Verdantas oversaw and coordinated a two-phase subsurface exploration program at the Woodland Dam facility. The program included of a total of 5 borings, identified as B-1, B-2, B-4, B-6, and B-8. The borings were completed on the island with the exception of boring B-8, which was located on the south side of the tail race. Site access for the majority of borings required entrance through the Woodland Dam facility which has low overhead clearance. This constraint resulted a limitation of the allowable drill rig size.

The first phase of the program took place from November 7 to 10, 2023, and consisted of three borings, identified as B-1, B-2, and B-8. The borings were drilled by New England Boring Contractors (NEBC) using an ATV Soil Scout for borings B-1 and B-2 and truck mounted B-53 drill rig for boring B-8. For each of these borings, drive and wash methods were utilized for drilling.

The second phase of the program took place took place from April 3 to 5, 2024, and consisted of three borings, identified as B-1 (to a deeper depth), B-4, and B-6. The borings were drilled by NEBC using an ATV Soil Scout. For each of these borings, driven casing and rock hammer methods were used for drilling.

The borings were advanced to depths ranging from 11.3 to 24.0 feet below ground surface (bgs). Split-barrel sampling via the Standard Penetration Test (SPT, American Society for Testing and Materials [ASTM] International D-1586-18) was conducted until the bedrock surface was encountered; however, sampling with the smaller ATV Soil Scout Rig utilized a rope and cathead drive that lead to some inconsistent and/or lower hammer fall heights. The summation of the blows necessary to collect the 6-inch to 18-inch depth interval of each SPT sample is called the Standard Penetration Number, which is used as an indicator of the soils' inherent in situ density; however, as mentioned about it should be understood that a shorter hammer drop height will lead to SPT values that are artificially higher than those completed with the standard 30-in hammer drop. Borings B-4 and B-6 did not have SPTs and were intended to visually confirm bedrock contact and quality and assess rock quality designation (RQD).

The approximate locations of the as-drilled boring locations are shown on **Figure 2**. Estimated coordinates of the borings were interpolated from Google Earth online data and elevations interpolated from the Existing Conditions Plan – Overall Site Plan provided in the Issue for Bid plan set.

A Verdantas field geologist or engineer oversaw the subsurface explorations, measured apparent groundwater levels, prepared field test pit and boring logs, and collected soil samples and rock cores. Soil samples were classified in general accordance with visual and manual procedures (ASTM D-2488) and described using modified Burmister Soil Classification System descriptors. The results of field sampling and Verdantas' field observations are presented on the final test pit and boring logs in **Appendix A**. Stratification lines shown on the boring logs represent approximate boundaries between soil types encountered. The actual transitions will likely be more gradual and may vary over short distances.

3.0 SUBSURFACE CONDTIONS

3.1 GENERAL

The profile and soil conditions outlined below highlight the major subsurface stratification at the Site. The individual boring logs should be consulted for detailed descriptions of the subsurface conditions encountered at each boring location. When reviewing the exploration record and subsurface profile, it should be understood that soil conditions might vary between and away from the boring locations. The findings of this report are less accurate when applied to areas not investigated as a function of increased distance away from the specific boring locations. Variations in subsurface conditions are possible laterally and with depths that are not identified on the boring logs or otherwise in this report.

3.2 OVERBURDEN SOILS

Overburden soil conditions encountered during the subsurface explorations are described below.

Fill: Each of the borings encountered fill, extending from the ground surface down to the interpreted bedrock surface (approximately 5.8 to 9.3 feet below ground surface). The fill varied in color and composition at different depths and at different boring locations. It was generally described as brown or gray sand, with varying amounts of gravel and rock fragments. There were cobbles/boulders and concrete fragments encountered frequently within this layer. The density of the fill layer ranged from relatively loose to dense. The fill did not exhibit characteristics indicative of controlled materials placed in a controlled manner.

3.3 BEDROCK

Cookson Group Formations: Bedrock was encountered in borings B-1, B-2, B-6, and B-8. The bedrock was identified as interbedded wacke and thinly laminated arenite. The depth to the bedrock surface ranged from 8 to 10 feet below ground surface (bgs). Rock cores were taken in 5 feet intervals, beginning at the bedrock surface and extending as deep 24 feet bgs (B-1). The RQD for each core run was calculated with ranges from 0% to 66%. A roller bit and air hammer were used to bypass a layer of rock too fractured for rock coring in borings B-1 and B-6, extending from 8 to 10 feet and 5 to 11 feet, respectively. Rock fractures when present appear to occur along bedding planes which dip at approximately 50-70 degrees from horizontal. This is consistent with bedrock geology mapping in the area that indicates similar dip angles in generally south to southeastern directions. Based on historical photographs and documentation, we believe that the existing retaining walls around the perimeter of the island are founded on rock. Based upon observations of exposed rock highly prevalent to the north and east of the island and review of historical imagery, the island likely represents a higher outcrop of bedrock that the Woodland facility was originally and purposefully constructed around over time.

3.4 GROUNDWATER

Groundwater was observed in the three borings during the November 2023 phase of the subsurface exploration. Groundwater was measured after drilling completion and recorded at 8.1 feet bgs, 9.2 feet bgs, and 5.8 feet bgs, for B-1, B-2, and B-8 respectively. These depths are interpreted to correlate approximately with the top of competent rock surface. Groundwater was not observed during the April 2024 phase of the subsurface exploration. It is common for water to accumulate on and flow across bedrock surfaces, particularly when the overburden material has a high hydraulic conductivity.

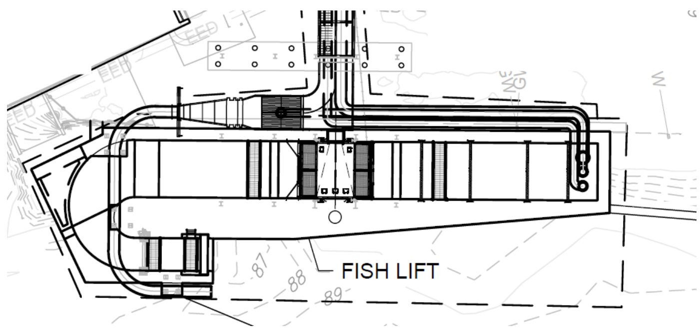
4.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

Based on our understanding of the project, we understand that there are five (5) main design components to consider: Fish Lift, Exit Flume, Fish Ladder, Pipe Supports, and Access Bridge Abutments. The Verdantas structural design team has indicated that they intend to utilize both shallow spread footings and deep foundations in supporting these components. Based on the composition of the on-site fill material, we recommend that it be removed entirely where shallow spread footings are planned and the structure be designed to bear on a prepared bedrock surface. The depth to bedrock on the island appears to be shallow enough in most places (but not all) to make this approach reasonable. Additionally, there will be components constructed on the banks or within the waterways.

Deep foundations are planned to consist of micropiles designed to transfer vertical structural loads through fill soils and into the bedrock surface. It should be noted that this report does not address the impact of the proposed structures constructed on the banks and/or waterways on river hydraulics. We assume that the scour potential for micropile supported foundations on the island is negligible given the adjacent dam structure controlling river elevations.

The following sections identify the recommended foundation system(s) for each of the five (5) main design components and provide specific design values and recommendations for each structure. Calculation sheets for design values are included in Appendix C.

4.1 FISH LIFT



The Fish Lift (inset right) is approximately 140-feet long with an east-west orientation. The proposed design for the fish lift indicates a bottom of concrete elevation ranging from El. 76.5 and El. 87. The existing grades shown on the Excavation Plan, indicate that the existing ground surface beneath the main body of the fish lift will be between El. 87 and El. 91; however, the existing ground surface elevation may be higher beneath the existing fish lift footprint on the edge of the island. Since the proposed Fish Lift footprint is primarily within the river, we assume there is no or negligible overburden present. This assumption is supported by the observed bedrock surface during drilling, bedrock outcrops present elsewhere in the river, historical photographs showing bedrock on the island, and observed bedrock outcrops along the riverbanks. Therefore, we recommend the main body fish lift utilize a shallow foundation bearing directly on rock. Provided that the rock surface is prepared in accordance with Section 5.0 of this report, a shallow foundation bearing on rock should meet the following design criteria.

SHALLOW FOOTINGS	
Design Criteria	**Recommended Design Value**
Bottom of Foundation Elevation	El. 76.5 – El. 87.0
Seismic Site Class	C
Bearing Capacity of Bedrock	8 tsf
Coefficient of Base Friction on Bedrock	0.6

It is assumed that all backfill around the structure will be imported structural fill, placed and prepared in accordance with Section 5.0 of this report. The lateral earth pressure recommendations provided below are applicable to the design of rigid retaining walls that are fixed against rotation and not allowed to deflect. The recommendations are not applicable to the design of geogrid reinforced walls and would be considered conservative for the design of walls that are allowed to rotate/deflect. Furthermore, we recommend that passive earth pressure for soil should be neglected given the relatively thin overburden adjacent to the river and the likelihood for scour. The following recommended design values apply to imported structural fill.

IMPORTED STRUCTURAL FILL	
Design Criteria	**Recommended Design Value**
Moist Unit Weight	135 pcf
Saturated Unit Weight	140 pcf
Internal Angle of Friction (ϕ')	34 degrees
At-Rest Coefficient (K_o)	0.44
Moist Equivalent Fluid Pressure	60 psf
Saturated Equivalent Fluid Pressure (Below GWT)	100 psf

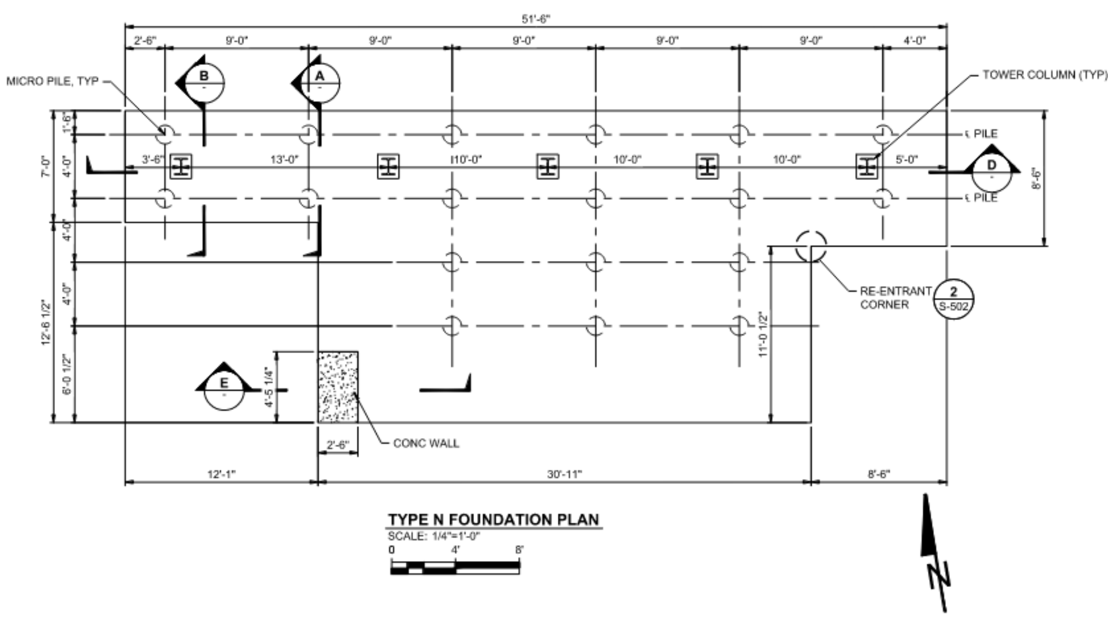
The structural design requires rock dowels to resist structural overturning of the fish lift. The rock dowels are spaced approximately 10 feet on-center and required to provide a maximum service load of 25 kips each in tension. These dowels are designed to provide passive resistance (i.e., not pre-tensioned) to the foundation. The rock dowels should be fully grouted and installed with the following minimum requirements:

Rock Dowel Support	
Design Criteria	**Recommended Design Value**
Minimum Drill Hole Diameter	4 inches
Minimum Grout Compressive Stress	4000 psi
Minimum Bond Length	10 feet
Reinforcing Bar Type	#8, 75ksi threadbar
Minimum Bar Area	0.79 in^2
Minimum Yield Strength of Bar	59 kips

4.1.1 Fish Lift Support Tower

The proposed design includes fish lift support towers located to the north of the main fish lift structure. Borings in the area indicate structurally unsuitable fill material up to 9.3 feet thick overlying bedrock. Based on the nature of the fill and proximity to existing structures, over excavation to install shallow spread footings is not anticipated to be practical. Therefore, we recommend the support towers utilize a micropile supported foundation system that transfers loads through the fill layer and into competent bedrock. This approach is anticipated to minimize disturbance to existing structures. The foundation should be protected from frost action in accordance with Section 4.7.

The micropiles were designed for the axial loads to be carried entirely within bedrock. The proposed foundation allows for center to center pile spacing that is greater than 6 times the pile dimeter, making group effects negligible. Refer to the diagram below for the proposed pile cap orientation.

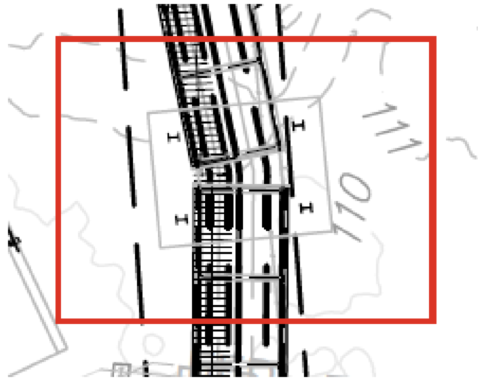


The structural design team provided design service load reactions for each of the piles. The micropiles were designed to carry the maximum compression (76 kips), tension (27.5 kips), lateral (10.6 kips) and bending (447 kip-inch) forces acting on a single pile, which is conservative given that individual piles may experience smaller loads than the design case. Furthermore, the structural model used a conservatively flexible pile cap that puts more load on individual piles, when the actual pile cap may distribute loads to the piles more evenly. The lateral pile responses of the piles were modeled in LPile (version 2019.11.09 by Ensoft, Inc.) to evaluate pile deflection and maximum bending moment. The analyses considered a pinned pile connection at the pile cap. The maximum loads were then run through a geo-structural evaluation to determine required material sizes, structural capacity of the cased and uncased segments of the pile and required bond length. This process is iterative and generally follows the procedures outlined in the Micropile Design and Construction Reference Manual for NHI Course 132078[1]. A detailed calculation package detailing our analysis and assumptions is provided in Appendix C. The following table summarizes the recommended micropile specifications.

FISH LIFT SUPPORT TOWER MICROPILES	
Design Criteria	**Recommendation**
Casing Type	API N-80 Pipe
Design Deflection	1 inch
Casing Outside Diameter	7-inches
Casing Inside Diameter	6-inches
Reinforcing Bar Type	#10 DSI Threadbar Epoxy Coated
Reinforcing Bar Nominal Yield Stress	75 ksi
Grout Strength	4 ksi
Cased Length	15-feet
Minimum depth of casing penetration into bedrock	5 feet
Minimum Uncased Length in bedrock	8-feet
Uncased Section Drill Hole Diameter	7-inches

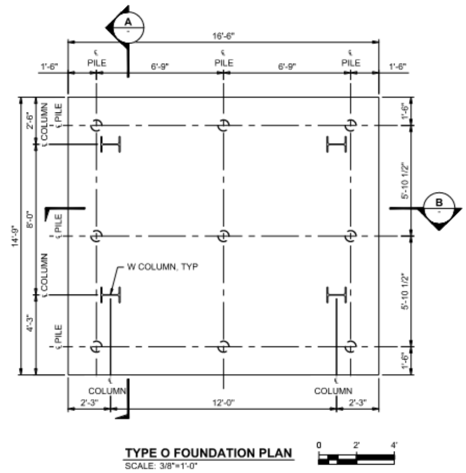
[1] US Department of Transportation Federal Highway Administration Micropile Design and Construction – Reference Manual National Highway Institute, NHI Course No. 132078 Publication No. FHWA NHI-05-039 December 2005

4.2 EXIT FLUME



The Exit Flume consists of approximately 200 feet of above ground exit flume and elevated piping that runs from the fish lift to the upstream waters (inset, right). The exit flume alignment is located entirely on the island to the north of the tailrace. Borings in the area of the alignment indicate structurally unsuitable fill material up to 9.3 feet thick overlying bedrock. Based on the nature of the fill and proximity to existing structures, over excavation to install shallow spread footings is not anticipated to be practical. Therefore, we recommend the support towers utilize a micropile supported foundation system that transfers load through the fill layer and into competent bedrock. The foundation should be protected from frost action in accordance with Section 4.7.

The micropiles were designed for the axial loads to be carried entirely within bedrock. The proposed foundation size for this structure is 16.5 feet by 14.75 feet and center to center pile spacing is greater than 6 times the pile dimeter, making group effects negligible. Refer to the diagram below for the proposed pile cap orientation.

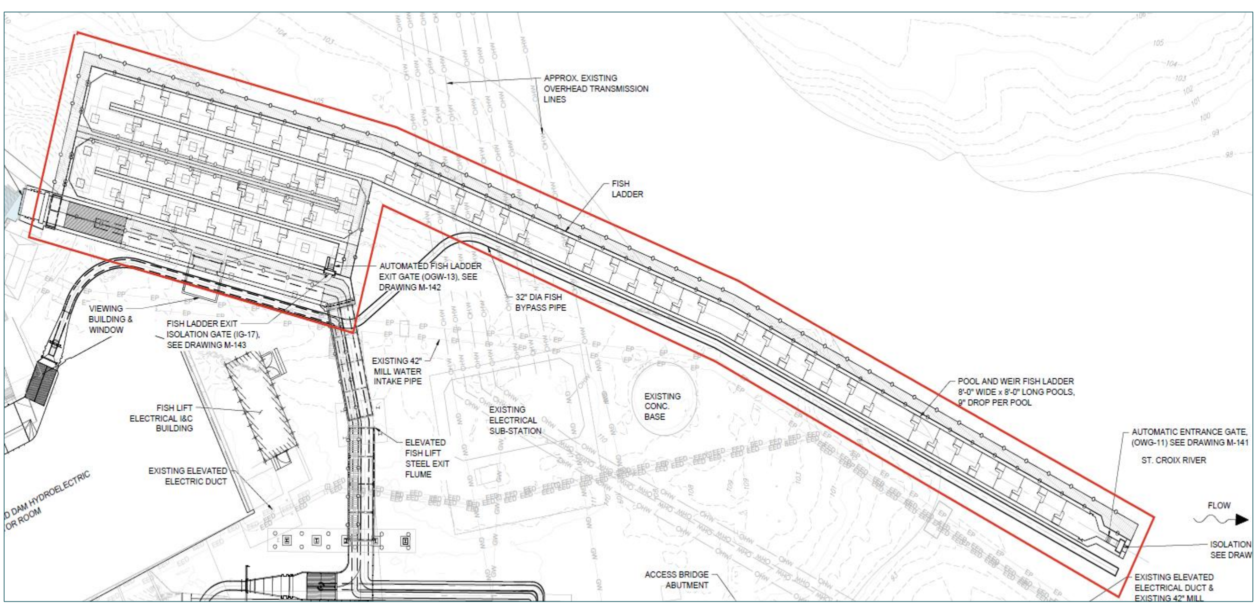


The structural design team provided design service load reactions for each of the piles. The micropiles were designed to carry the maximum compression (80 kips), tension (7 kips), lateral (8 kips) and bending forces (304 kip-inch) acting on a single pile, which is conservative given that individual piles may experience smaller loads than the design case. Furthermore, the structural model used a conservatively flexible pile cap that puts more load on individual piles, when the actual pile cap may distribute loads to the piles more evenly. The lateral pile responses of the piles were modeled in LPile to evaluate pile deflection and maximum bending moment. The analyses considered a pinned pile connection at the pile cap. The maximum loads were then run through a geo-structural evaluation to determine required material sizes, structural capacity of the cased and uncased segments of the pile and required bond length. This process is iterative and generally follows the procedures outlined in the Micropile Design and Construction Reference Manual for NHI Course 132078[1]. A detailed calculation package detailing our analysis and assumptions is provided in Appendix C. The following table summarizes our recommended micropile specifications.

EXIT FLUME MICROPILES	
Design Criteria	**Recommendation**
Casing Type	API N-80 Pipe
Design Deflection	0.6 inch
Casing Outside Diameter	7-inches
Casing Inside Diameter	6-inches
Reinforcing Bar Type	#10 DSI Threadbar Epoxy Coated
Reinforcing Bar Nominal Yield Stress	75 ksi
Grout Strength	4 ksi
Minimum Cased Length	15-feet
Minimum Depth of Cased Penetration into Bedrock	5-feet
Minimum Uncased Length in Bedrock	8-feet
Uncased Section Drill Hole Diameter	7-inches

4.3 FISH LADDER

The Fish Ladder spans over 400 feet from east to west and drops approximately 47 feet from its upstream invert to its downstream invert (inset, below). The fish ladder will be supported by concrete columns transferring loads to or founded directly on the acceptable ground surface where applicable.



The proposed Fish Ladder is aligned over the existing fish ladder, along the banks of the river, and within the river, along the north side of the island.

The areas where the new fish ladder will be located were not readily accessible for drilling (or other intrusive explorations) and as such there is not specific geotechnical data available to devote toward its foundation design. Therefore, our nearby field data and overall observations were extrapolated to these areas. As described previously, there was less than 10 feet of rubble fill observed in Verdantas' borings overlying poor quality bedrock on the island. However, it is anticipated that there is minimal overburden along within the river channel in the area of the fish ladder and the bedrock may be higher quality as poor-quality materials may have been scoured away by the river. Furthermore, it is understood that the existing fish ladder was founded directly on bedrock. Based upon these conditions, we recommend that the foundations the proposed Fish Ladder be founded directly on bedrock since existing overburden (if present) is expected to be thin, or unsuitable (i.e., prevalent cobbles and boulders), to support a foundation. This assumption is supported by the nature of the observed bedrock surface during drilling, bedrock outcrops present elsewhere in the river, historical photographs showing bedrock on the island, and observed bedrock outcrops along the riverbanks. Our design evaluations indicated that the large axial and lateral piles loads generated during a seismic event, and the relatively small area available for footings, made micropiles an unideal option. Therefore, we recommend that the Fish Ladder be designed to be supported by shallow foundations bearing directly on bedrock. The following table summarizes the recommended design criteria for the shallow foundation design.

SHALLOW FOOTINGS	
Design Criteria	**Recommended Design Value**
Bottom of Foundation Elevation	On bedrock/Variable Approximately El. 117 to El. 87
Seismic Site Class	C
Bearing Capacity of Bedrock	8 tsf
Coefficient of Base Friction on Bedrock	0.6

It should be understood that the values are likely conservative as they are provided for poor to very poor quality rock, and it is anticipated that the rock quality along the alignment of the Fish Ladder is likely better quality that the rock encountered in the field investigations.

It is assumed that backfill will be imported structural fill, placed and prepared in accordance with Section 5.0 of this report. The following are recommended design values for imported structural fill.

IMPORTED STRUCTURAL FILL	
Design Criteria	**Recommended Design Value**
Moist Unit Weight	135 pcf
Saturated Unit Weight	140 pcf
Internal Angle of Friction (ϕ’)	34 degrees
At-Rest Coefficient (K_o)	0.44
Moist Equivalent Fluid Pressure	60 psf
Saturated Equivalent Fluid Pressure (Below GWT)	100 psf

4.4 ACCESS BRIDGE

As described previously, a new bridge is proposed to facilitate construction equipment access to the island from the mill facility riverbank. We understand that the bridge will remain in-place following construction, providing permanent access to the island. The proposed access bridge will be a two-span structure: the first span will be approximately 67 feet long and span from an existing mill building driveway to a new pier to be constructed at the southern riverbank of the tail race; and the second span will be approximately 160 feet long, from the pier to an abutment on the island at the north riverbank of the tail race .

The surface elevation of the riverbed at the northernmost bridge abutment indicates that the bedrock surface is approximately EL. 89 ft within the river and El. 95 ft on the island. The northern abutment footing is not rectangular in shape but fits within an approximately 12 feet wide by 27.5 feet long, with a bottom of footing elevation at El.87. The pier footing is approximately 11 feet wide by 26.5 feet long, with a bottom of footing elevation of approximately El. 93. Boring data (i.e., B-8) and exposed rock along the southern bank of the tail race indicates that bedrock surface is approximately EL. 102 in the vicinity of the mill facility and drops towards the river to approximately EL. 93. The southern abutment is approximately 15.5 feet wide by 26.5 feet long, with a bottom of footing elevation at El.103. Boring data in the vicinity of the southern abutment indicates that bedrock surface is approximately EL. 103. We understand that the foundation supports are planned to utilize shallow foundations bearing directly on prepared bedrock. Based on the variation of the bedrock surface encountered during construction, the project team may deem it necessary or preferable to step the footing at the pier to reduce the amount of rock excavation required.

Provided that the rock surface is prepared in accordance with Section 5.0 of this report, a shallow foundation bearing on rock shall be designed with the following criteria.

SHALLOW FOOTINGS	
Design Criteria	**Recommended Design Value**
Bottom of Foundation Elevation	Northern Abutment: El. 87 Pier: El. 93 Southern Abutment El. 103
Seismic Site Class	C
Allowable Bearing Capacity of Bedrock	8 tsf
Allowable Shear Resistance of Bedrock	8,000 psf
Coefficient of Base Friction on Bedrock	0.6

It is assumed that all backfill around the abutments and wingwalls will be imported structural fill, placed and prepared in accordance with Section 5.0 of this report. The lateral earth pressure recommendations provided below are applicable to the design of rigid retaining walls that are fixed against rotation and not allowed to deflect. The recommendations are not applicable to the design of geogrid reinforced walls and would be considered conservative for the design of walls that are allowed to rotate/deflect. Furthermore, we recommend that passive earth pressure for soil should be neglected given the relatively thin overburden adjacent to the river and the likelihood for scour. The following are recommended design values for imported structural fill.

IMPORTED STRUCTURAL FILL	
Design Criteria	**Recommended Design Value**
Moist Unit Weight	135 pcf
Saturated Unit Weight	140 pcf
Internal Angle of Friction (ϕ’)	34 degrees
At-Rest Coefficient (K_o)	0.44
Moist Equivalent Fluid Pressure	60 pfc
Saturated Equivalent Fluid Pressure (Below GWT)	100 pfc

The structural design requires 4 rock dowels to resist structural overturning of the northern abutment wall. The rock dowels are spaced approximately 7.75 feet on-center and required to provide a maximum service load of 94 kips. These dowels are designed provide passive resistance (i.e., not pre-tensioned) to the foundation. The rock dowels should be fully grouted and installed with the following minimum requirements:

Rock Dowel Support	
Design Criteria	**Recommended Design Value**
Minimum Drill Hole Diameter	4 inches
Minimum Grout Compressive Stress	4000 psi
Minimum Bond Length	20 feet
Reinforcing Bar Type	T52N B7Y1 Non-Domestic Hollow Injection Bar
Minimum Bar Area	1.874 in^2
Minimum Yield Strength of Bar	164 kips

4.5 PIPE SUPPORTS

The proposed project development includes a variety of ancillary pipe utilities supporting the overall project development. We understand that these pipes will be supported by the proposed structures, but there are locations that will require independent support foundations (e.g., just outside of the fish lift footprint [to the north]). The pipe support foundations should consist of shallow spread footings bearing on bedrock or prepared and approved existing fill and be protected from frost action in accordance with Section 4.7.

SHALLOW FOOTINGS for Pipe Supports	
Design Criteria	**Recommended Design Value**
Bottom of Foundation Elevation	Minimum 5 feet below proposed finished grade.
Seismic Site Class	C
Allowable Bearing Capacity	2000 psf*
Estimated Settlement	Less than 0.5 inch
Coefficient of Base Friction	0.6
*After proper preparation of the subgrade.	

4.6 ACCESS ROAD APPROACH

The proposed southern access road approach to the Access Bridge will be elevated above surrounding grade through the use of a “U” shaped concrete retaining wall section. Based on Boring B-8, there is approximately 5 to 6 feet of fill materials overlying weathered bedrock. The fill should be removed from beneath the wall foundation(s) and the wall foundation(s) should be founded on bedrock, weathered, rock; or structural fill placed above weathered rock or bedrock. The access road approach is anticipated to be relatively lightweight, so bearing capacity and settlement of the structure are not a concern provided proper subgrade preparation, as discussed in Section 5. The foundations should be protected from frost action in accordance with Section 4.7.

4.7 FOUNDATION FROST PROTECTION

The design frost depth for the Site is 5 feet below ground surface. Foundations that are founded above this depth and not bearing directly on bedrock should be protected against frost action. There are two options for providing frost protection: the first is to set the bottom of foundation below the frost depth; the second option is to provide well-draining foundation soil and insulation using extruded polystyrene foam board. The existing soils on Site are assumed to be well-draining and the water table is interpreted to be located along the bedrock surface and below the frost line. As of the date of this report, it is understood that the insulated foundation option is being pursued for each of the micropile supported foundations. The insulated foundation should consist of a minimum 2-inch extruded polystyrene foam board (or similar insulation capacity), atop a minimum 1 foot of free draining granular soil. The insulation should extend at least three feet laterally from all sides of the foundation. We understand that other foundations which are planned to bear on soil will be embedded below the frost line.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 GENERAL SITE PREPARATION

Topsoil, organic matter, debris (including possible old demolition materials), frozen soils, and loose or disturbed soils and rocks should be removed from areas receiving new construction. Certain materials removed during Site stripping operations may be used as common fill, provided they meet the requirements for common fill described herein.

Existing, active underground utilities are present throughout the Site. The sitework/foundation contractor (herein referred to as the contractor) should be aware of the potential for underground structures to be present throughout the Site and take the necessary precautions to avoid damaging the existing utilities that will remain in use after Site development. Where practical, underground utilities present below the proposed structure footprints should be relocated outside the structure perimeters. Additionally, there are structures on the island related to existing infrastructure, and these structures have independent foundations, anchors, supports, and/or guywires that must be protected during the new construction.

5.2 TEMPORARY EXCAVATIONS

The overburden soils on the Site are predominately loose, granular soils and possible demolition debris, and contain voids. Excavations should be cut to a stable slope or be temporarily braced, depending upon the excavation depths and the subsurface conditions encountered. Temporary construction slopes should be designed in compliance with applicable governing regulations including the Occupational Safety and Health Administration (OSHA). Based upon the soil samples recovered from the borings, the near-surface soils should be considered OSHA Type C soils. Temporary excavations should be sloped at not steeper than 1.5H:1V for excavations to a maximum depth of 20 feet bgs under dry, dewatered conditions.

We understand that portions of the existing retaining wall structures are intended to be left in place and potentially utilized as excavation support. We are unaware of the structural integrity of the existing walls and recommend that the contractor be prepared to stabilize and/or reinforce the existing walls if they are intended to remain in place. The contractor phasing plan and schedule should account for the uncertainties associated with these walls.

Stockpiles should be placed at a distance away from the top of the excavation that is equal to at least the depth of the excavation. Surface drainage should be controlled to avoid flow of surface water into the excavations. Construction slopes should be reviewed for signs of mass movement, such as tension cracks near the crest or bulging at the toe. If potential stability problems are observed, work should cease, and the project geotechnical engineer should be contacted immediately. The responsibility for excavation safety and stability of temporary construction slopes should lie solely with the contractor. Excavations performed along the tail race or river must be coordinated with Woodland operations and closely scheduled to avoid high water conditions from precipitation events upstream.

5.3 BEDROCK EXCAVATION

Bedrock preparation/excavation should be anticipated for all design components utilizing shallow foundations. This includes the fish lift, fish ladder, access bridge abutments, and ancillary pipe supports. Given the fractured nature of the rock and the proximity of the Work to the dam, blasting of the rock is non-advisable, and alternative rock excavation methods should be considered. Mechanical methods, such as using a large excavator with a ripping tooth, or a hydraulic hoe ram and/or line drilling, can likely complete the rock excavation in a reasonably efficient manner. The use of line drilling should be used to create a relatively clean face and prevent overbreak, given the close proximity of the excavations to the existing structures.

The contractor should be made aware that bedrock is anticipated to have generally bedding/fracture plane orientation. Bedrock mapping indicates the rock plane to slope down from the north-northeast to the south-southwest at angles ranging from 36-68 degrees. The contractor should be aware that there may be a potential for rock to slide when excavating into the rock surface and the contractor should be prepared to implement temporary stabilization measures (e.g., shotcrete or dowels/pins), if warranted.

We strongly recommend the contractor familiarize themselves with the bedrock excavation conditions before construction. In addition, the contractor's project phasing should clearly define bedrock excavation, particularly as it pertains to their means and methods.

5.4 ROCK SURFACE PREPARATION

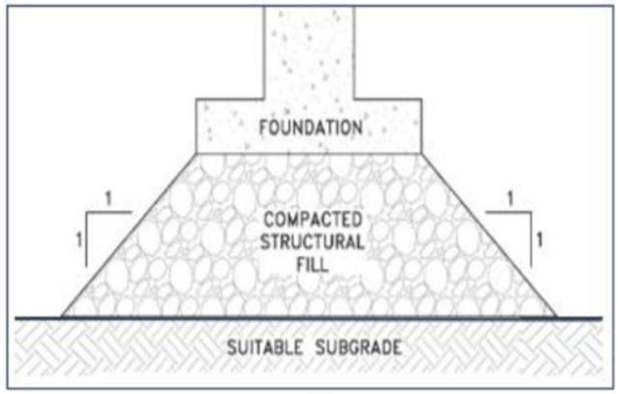
The following section describes surface preparation requirements for shallow foundations designed to bear directly on prepared, intact bedrock. After stripping of overburden soils and removal of bedrock to achieve foundation bearing elevations, the bedrock surface should be cleared of loose rock and significantly weathered/ "rotten" zones prior to the construction of foundations. Where bedrock is not present at minimum foundation burial depth, the foundation wall should be extended downward to the top of the bedrock surface.

The prepared bedrock surfaces should be air blasted or swept to promote direct adhesion of cured concrete to the rock: this will be of particular importance where the foundation is subject to lateral forces. Voids in the bedrock should be filled with lean concrete prior to placing foundation concrete to provide a more workable surface for the placement of reinforcement and estimation of required volume of foundation concrete. Bedrock surfaces below foundation areas should slope no greater than 5H:1V. Bedrock slopes steeper than 5H:1V should be benched to provide relatively flat bearing surface. Dowels to proposed structures, if required, should be designed by the structural engineer. We recommend that dowels, if required, consist, at minimum, of epoxy coated #4 bars; drilled 12-inches into competent rock and set into epoxy; are spaced not more than 4-feet on-center; and extent at least 18-inches into the foundation concrete.

5.5 SOIL SUBGRADE PREPARATION

The overburden materials on the island are expected to contain cobbles/boulders and concrete fragments. While soils on the southern side of the tail race are anticipated to consist of loose fills overlying weathered rock and bedrock. As such it is possible that voids could be encountered at the proposed bottom of excavation elevations. If encountered, the contractor should be prepared to install choker stone to fill and bridge voids, and the resulting surface should be proof-rolled and overlain with a non-woven geotextile fabric such as Mirafi 160N, or equivalent.

Subgrades consisting of stable undisturbed soils should be aggressively proof-rolled with at least six passes (three each way in perpendicular directions) of a minimum 10-ton vibratory roller in open areas, or a 1-ton vibratory roller or large plate compactor in trenches.



During the proof-rolling process, the subgrades should be reviewed to identify soft or unstable areas. Unsuitable areas (e.g., soft fines, saturated soils, and organics) should be over-excavated to more competent material and be replaced with compacted structural fill, as needed. Where exposed native soils are observed to be saturated, proof-rolling should not include the use of vibration. Over-excavation, if necessary, should include the foundation bearing zones (defined as the 1 horizontal to 1 vertical line extending down and away from the bottom outside edges of footings and slabs to the top of suitable soils; refer to Diagram inset right). Following proof-rolling, compacted structural fill may be placed in the bearing zones to achieve design cast-in-place footing/slab/roadway section subgrade elevations, as needed.

5.6 FILL AND BACKFILL

General: Compacted structural fill should be used as new fill or backfill where existing materials are unsuitable to support formwork or new load bearing structures. Crushed stone may be used in lieu of structural fill at the direction of the project geotechnical engineer or his/her representative where subgrades become saturated and over-excavation of saturated soils is not feasible. Crushed stone, if used, should be wrapped in a geotextile filter fabric, such as Mirafi 160N or equivalent, to reduce the potential for migration of fine-grained particles into the voids present within the stone.

Walls should be backfilled evenly on both sides to the extent practical. Only manual compactors, such as “Jumping Jacks” and walk-behind plate vibrators should be used within 2 feet of foundation walls and columns. Heavy equipment wheel loads such as from loaded dump trucks, concrete trucks, or material delivery trucks, should maintain a setback of at least 6 feet from foundation walls.

Bedding placed below utilities should be in accordance with the local utility or manufacturer requirements. In general, new utilities may be supported by compacted structural fill, or other suitable pipe bedding materials. Fill placed as backfill for utilities may consist of compacted common fill after the pipe is surrounded by proper bedding soil.

Soil Reuse: Based upon visual classification of the soils observed in the borings, a portion of the existing overburden soils may be suitable for reuse only as common fill: they would need to be primarily granular and stable after compaction, and be free of organic material and large particles that could create voids during reuse. Reused overburden soils from the Site are not to be used as fill beneath any load bearing structures nor as backfill against structures. The area considered “load bearing” shall extend at a 1H:1V slope down and away from the bottom of any footing.

Excavated soils intended for reuse will need to be properly stockpiled, dried, moisture conditioned, etc., in order to achieve adequate compaction during placement.

Structural Fill: Structural fill shall consist of sand or gravel of hard, durable particles free from vegetative matter, lumps or balls of clay, frozen material and other deleterious substances.

STRUCTURAL FILL	
Sieve Size	**Percent Passing**
3 inches	100
1 inch	60-100
No. 4	35-85
No. 10	25-75
No. 20	15-60
No. 40	10-45
No. 100	5-25
No. 200	3-10
Note: Maximum 3-inch particle size within 12 inches of foundation and slab subgrade elevations.	

Structural fill should be placed in loose lifts not exceeding 12-inches in thickness for self-propelled vibratory rollers and 8-inches for vibratory plate compactors. Structural fill placed below footing bearing zones should be compacted to at least 95 percent of maximum dry density +/3% of optimum moisture content as determined by ASTM D 1557, Method C.

Common Fill: Excavated inorganic, granular soil from the Site may be selectively reused as common fill provided it is inorganic, free of deleterious materials, and can be adequately compacted. Common fill should consist of soil free from frozen soil, debris, or other deleterious material. The maximum particle size is recommended to be 6 inches, and no more than 30 percent by weight should pass the No. 200 sieve. Common fill may be used to achieve finished grades outside of the design component footprints and beyond 24 inches laterally from the outside of all foundations.

Common fill should be placed in loose lifts not exceeding 12 inches in thickness for self-propelled vibratory rollers and 8 inches for vibratory plate compactors, and compacted to at least 95 percent of maximum dry density +/5% of optimum moisture content as determined by ASTM D 1557, Method C.

5.7 Micropile Installation

Construction of deep foundation units should be closely monitored by the geotechnical engineer or his/her representative in order to observe construction methods and to verify subsurface conditions are as observed in the test borings. It will be important to verify foundation element installation depths in order to achieve the desired allowable design capacities recommended herein, including top of bedrock elevation and pile penetration into bedrock.

Based upon the subsurface conditions observed in the test borings, the use of a pneumatic down-hole hammer may be required to facilitate installation of the piles through obstructions encountered in the overburden fill soils, as well as to drill piles into bedrock to achieve the recommended design load capacities. The pipe pile installation contractor should be equipped with suitable equipment for installing the piles through obstructions, such as a Numa Super Jaws® drill bit, or equal.

Concrete or grout used in the drilled pipe pile construction should have suitable flow and workability characteristics so that positive encapsulation around the reinforcing steel is achieved and potential for voids is reduced. The concrete/grout head in the casing should be maintained at a vertical head at least 5 feet greater than the external hydrostatic pressure. Grouted pipe pile defects are frequently the result of inadequate head of concrete/grout, low flowability of the concrete/grout, or a combination of the two. The applied pressure head should be carefully monitored throughout the concrete/grout placement process to promote proper delivery and distribution of the grout.

The contractor should maintain a record of voids, fractures, and weak zones as documented by the micropile drill rig operator during each micropile installation. Note that a weak zone is defined as sudden loss of pressure or rapid advancement of the tooling equipment that indicates low resistance. The contractor should also maintain a record of penetration rate, torque, and/or other penetration resistance with depth. During grouting, all grout loss must be recorded. These data should be kept as the as-built record for the micropile.

5.8 ROCK ANCHORS AND PINS

At the date of this report, we anticipate the use of rock anchors and pins is not expected to be widespread. However, it is possible that conditions encountered during construction could vary from design assumptions and warrant design changes. It is anticipated that grouted rock anchors or dowels could be designed to pin unstable rock into place or to provide additional lateral or pull-out resistance for foundation systems as warranted. The Geotechnical Engineer should be made aware of any conditions that differ from the conditions described herein as soon as they are discovered. The contractor must keep a stock of anchors, pins, epoxy and grout at the Site as a contingency for these conditions.

5.9 EARTHWORK IN WET CONDITIONS

It is anticipated that full-time/sustained construction dewatering will be required for the portions of construction that are within, or directly adjacent to the St. Croix River. Groundwater was not encountered within the overburden soil layer of the peninsula; however, groundwater could be expected if the level of the surrounding surface waters is abnormally high. It may be necessary to temporarily dewater excavations within the island under these conditions. Similarly, it is possible that micropile drilling may intercept fractures connected to water head retained behind the dam, and in that case, the drill hole will need to be packed off prior to installation of the micropile.

We understand that temporary cofferdams are expected to be utilized for the portions of construction located within the St. Croix River. In general, it should be practicable to accomplish construction dewatering, once cofferdams are installed, through sumps and open pumping methods. The contractor should be required to maintain groundwater at least 2 feet below excavation subgrades, or at the top of bedrock, in order to minimize bearing surface disturbance. Construction dewatering should be initiated prior to general excavation work for structures within the river and should be maintained until completion of the associated underground construction and backfilling. Where applicable, groundwater should not be allowed to up well into excavations, as upwelling of groundwater will interfere with the placement of concrete.

The use of crushed stone at the base of excavations will facilitate dewatering, if necessary. Crushed stone, if used, should be wrapped in a geotextile filter fabric, such as Mirafi 160N, or equal. The use of crushed stone on bedrock surfaces must be approved by the structural engineer to verify that it will not unacceptably decrease the lateral friction resistance between the foundation and the subgrade.

Surface water runoff should be directed away from excavations to reduce potential dewatering efforts and protect subgrades from becoming soft and unstable. When utilized, trenches, ditches, and other groundwater or stormwater control systems should be carefully planned and designed so as not to conflict with new areas to be excavated and/or backfilled. Dewatering discharges must be managed in accordance with applicable permits and regulations.

6.0 LIMITATIONS

Verdantas provided the recommendations contained within this report based upon an evaluation of subsurface conditions observed and/or reported and their relation to proposed construction, as documented in the report text, and attached materials. The evaluations described and recommendations made in this report pertain to the specific areas explored. Verdantas believes the subsurface explorations and evaluations described herein were performed in a manner consistent with the services that would have been provided by other geotechnical professionals under similar circumstances. However, given the variable nature of native soil deposits and rock formations, we cannot represent that the subsurface conditions identified in the boring logs and described in this report are exact, nor can we guarantee that our interpolation between or extrapolation from subsurface exploration locations is completely representative of actual conditions.

Participation by the geotechnical engineer should be considered an important aspect of successfully designing and constructing the project. In particular, if the geotechnical engineer is not engaged by the project team during the design or during construction to perform foundation construction inspections, it should be understood that there may be missed opportunities to recognize unexpected conditions in a timely manner that may otherwise allow for corrective actions to be implemented at minimum cost.

Should additional information become available regarding the proposed Site development that is significantly different from that described in this report, or should subsurface conditions be found during construction that vary significantly from those observed during the subsurface explorations and summarized in this report, Verdantas should be given the opportunity to evaluate the data and modify its recommendations, if warranted.

This report has been prepared for specific application to the Site of the proposed project at the Woodland Pulp Dam on the St. Croix River in Baileyville, Maine. No other warranty, expressed, or implied, is made. In addition, this report was prepared exclusively for MEDMR and the associated project team. The use of this report by other parties without written consent from Verdantas is hereby prohibited.

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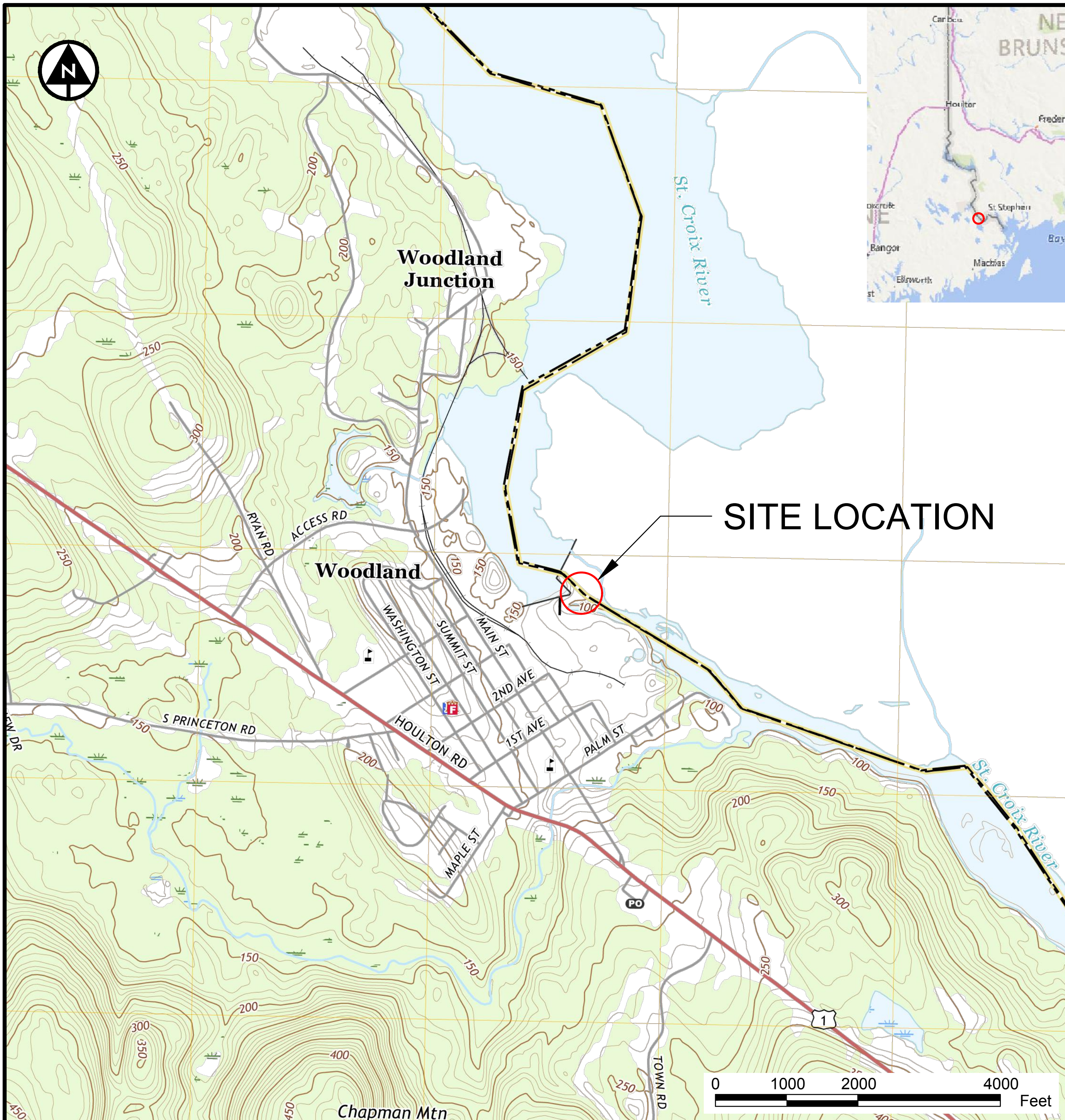
Date: December 2, 2024

Figures



SOURCE:

1. USGS WOODLAND QUAD 2021

Baileyville~Aroostook County~Maine

WOODLAND FISH PASSAGE SITE LOCUS

Woodland Dam
St. Croix River

Project Number	16667
Date	August 13, 2024
Author	LTV
Scale	1" = 2000'
Figure	1

Produced Using Autodesk's Civil 3D Software

LEGEND:

BORING LOCATION

NOTES:

1. BORING LOCATIONS APPROXIMATED FROM GOOGLE EARTH.

0 20 40 80 Feet

verdantas

Baileyville~Aroostook County~Maine

WOODLAND FISH PASSAGE
BORING LOCATION PLAN

Woodland Dam
St. Croix River

Project Number	16667
Date	August 13, 2024
Author	LTV
Scale	1" = 40'
Figure	2

z:\project files\ma-nz\medmr\16667 - woodland fish lift design\working\geotechnical investigation\figures\woodland - boring location plan.dwg 8/13/2024 11:20 AM

Produced Using Autodesk's Civil 3D Software

Appendix A
Boring Logs

SOIL BORING LOG

verdantas	**Client:** Maine Department of Marine Resources	**Boring Identification:** B-1
	Project: Woodland Fish Passage Design	**Sheet:** 1 of 1
	Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** CJS **Project Number:** 16667

Drilling Company: New England Boring Contractors	**Boring Location Lat/Long:** 45.15851173°/ -67.40196874°
Foreman: Devon Share	**Ground Surface Elevation:** 109' **Datum:** NAVD88
Verdantas Engineer/Geologist: Begum Kurtoglu	**Date Started:** 11/07/2023 **Date Completed:** 11/08/2023

DRILLING METHOD	SAMPLER
Vehicle: M1	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: Drive and Wash 4" and 3"	**Fall (in):** 24*

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
11/08/2023	8.1	Ground Surface	After Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0	S1	24/11	0 - 2	3, 10, 13, 19	S1: Medium dense, brown and gray, fine to coarse SAND, some Gravel and Rock Fragments, little Silt, dry.	FILL		
2	S2	24/7	2 - 4	11, 18, 31, 26	S2: Dense, beige and gray, fine to coarse SAND, some Rock Fragments, little Gravel, trace Silt, dry. **Note:** Concrete fragments encountered at the tip of the spoon.			
4	S3	24/0	4 - 6	6, 8, 4, 18	S3: No recovery.			
6	S4	24/1	6 - 8	22, 15, 10, 11	S4: Medium dense, gray, ROCK FRAGMENTS, little Gravel and Sand, damp. **Note:** Bedrock encountered at 8.2 ft below ground surface. Coring started at 8.2 ft below ground surface.			
8.2	C1	33/24	8.2 - 10.9	-	C1: Gray, fine-grained, WACKE and ARENITE, moderately soft, moderately weathered, 6.3 fractures per foot (RQD: 0%; Very Poor) [Cookson Group]. Rock Coring Rate (min:sec) 8.2 - 9.2 ft: 07:15; 9.2 - 10.2 ft: 07:37; 10.2 - 10.9 ft: 10:39	BEDROCK		
10.9	C2	7/7	10.9 - 11.5	-	C2: Gray, fine-grained, WACKE and ARENITE, moderately hard, highly weathered, 6.7 fractures per foot (RQD: 0%; Very poor) [Cookson Group]. Rock Coring Rate (min:sec) 10.9 - 11.5 ft: 15:03			
11.5	C3	25/20	11.5 - 13.6	-	C3: Gray, fine-grained, WACKE and ARENITE, moderately hard, moderately weathered, 4.3 fractures per foot (RQD: 0%; Very Poor) [Cookson Group]. Rock Coring Rate (min:sec) 11.5 - 11.9 ft: 06:26; 11.9 - 12.9 ft: 07:25; 12.9 - 13.6 ft: 07:42			
13.6					Boring terminated at 13.6 ft bgs.			
20								

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	Density	Blows/ft.	Consistency
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring terminated at 13.6ft. Boring backfilled with cuttings to ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface

* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be correlated to standard N-values

SOIL BORING LOG

verdantas PEOPLE FOCUSED FUTURE

Client: Maine Department of Marine Resources	**Boring Identification:** B-1 (Offset)	
Project: Woodland Fish Passage Design		**Sheet:** 1 of 2
Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** CJS	**Project Number:** 16667
Drilling Company: New England Boring Company	**Boring Location Lat/Long:** 45.15851173°/ -67.40196874°	
Foreman: Tom	**Ground Surface Elevation:** 109'	**Datum:** NAVD88
Engineer/Geologist: Joel Morin	**Date Started:** 4/3/24	**Date Completed:** 4/4/24

DRILLING METHOD	SAMPLER
Vehicle: ATV	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: SSA/Driven casing/rock hammer	**Fall (in):** ~18

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
04/04/2024	Not observed	Ground Surface	During Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0–5					**Note:** Solid stem auger to 5 ft bgs; casing driven to 5 ft bgs.	FILL		
5	S1	24/2	5-7	5	S1: Loose*, brown, GRAVEL and silty SAND, moist.	FILL		
				4				
				9				
				8				
8					**Note:** Bedrock encountered at 8 ft bgs; air hammer to 10 ft bgs.	HIGHLY FRACTURED BEDROCK		
10	C1	60/60	10-15	-	C1: Gray/light gray, fine to coarse grained, interbedded WACKE and thinly laminated ARENITE, Several core barrel jams, and starting and stopping to clear jams [Cookson Group]. Estimated Recovery: 100% RQD: 8%. Rock Coring Rate (min:sec) 10-11 ft 1:03; 11 - 12 ft 5:42; 12 - 13 ft 7:35; 13 - 14 ft 9:32; 14 - 15 ft 12:05 **Note:** 14-15 ft, Sheen observed on extracted cored rock and in water exiting borehole.	BEDROCK		
15	C2	51.6/50.5	15-19.3	-	C2: Gray/light gray, fine to coarse grained, interbedded WACKE and thinly laminated ARENITE, Several core barrel jams, and starting and stopping to clear jams [Cookson Group]. Recovery: 98% RQD: 66%. Rock Coring Rate (min:sec) 15 - 16 ft 3:36; 16 - 17 ft 6:12; 17 - 18 ft 5:23; 18 - 19.3 ft 8:45	BEDROCK		
20								

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	Density	Blows/ft.	Consistency
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring backfilled with cuttings to the ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface
* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be corelated to standard N-values

SOIL BORING LOG

verdantas			
Client: Maine Department of Marine Resources		**Boring Identification: B-1 (Offset)**	
Project: Woodland Fish Passage Design			**Sheet:** 2 of 2
Location: Woodland Dam, St. Croix River, Baileyville, Maine		**Checked By:** CJS	**Project Number:** 16667

Drilling Company: New England Boring Company	**Boring Location Lat/Long:** 45.15851173°/ -67.40196874°	
Foreman: Tom	**Ground Surface Elevation:** 109'	**Datum:** NAVD88
Engineer/Geologist: Joel Morin	**Date Started:** 4/3/24	**Date Completed:** 4/4/24

DRILLING METHOD	SAMPLER
Vehicle: ATV	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: SSA/Driven casing/rock hammer	**Fall (in):** ~18

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
04/04/2024	Not observed	Ground Surface	During Drilling

DEPTH (ft)	SAMPLE INFORMATION #	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
20	C3	60/60	19.3-24.3	-	C3: Gray/light gray, fine to coarse grained, interbedded WACKE and thinly laminated ARENITE, Few core barrel jams, and starting and stopping to clear jams [Cookson Group]. Recovery: 100% RQD: 44%. Rock Coring Rate (min.sec) 19.3 - 20.3 ft 6:21; 20.3 - 21.3 ft 5:06; 21.3 - 22.3ft 4:44; 22.3 - 23.3 ft 4:27; 23.3 - 24.3 ft 4:35	BEDROCK		
21								
22								
23								
24					Boring terminated at 24 ft bgs.			
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

GRANULAR SOILS Blows/ft.	Density	COHESIVE SOILS Blows/ft.	Consistency
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring backfilled with cuttings to the ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface
* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be corelated to standard N-values

SOIL BORING LOG

verdantas PEOPLE FOCUSED FUTURE

Client: Maine Department of Marine Resources	**Boring Identification:** B-2
Project: Woodland Fish Passage Design	**Sheet:** 1 of 1
Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** CJS **Project Number:** 16667
Drilling Company: New England Boring Contractors	**Boring Location Lat/Long:** 45.15849158˚/ -67.40179781˚
Foreman: Devon Share	**Ground Surface Elevation:** 110' **Datum:** NAVD88
Verdantas Engineer/Geologist: Begum Kurtoglu	**Date Started:** 11/09/2023 **Date Completed:** 11/09/2023

DRILLING METHOD	SAMPLER
Vehicle: M1	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: Drive and Wash 4" and 3"	**Fall (in):** 24*

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
11/09/2023	9.2	Ground Surface	After Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0	S1	24/6	0 - 2	3 29 17 13	S1: Dense, brown, GRAVEL and fine to coarse SAND, trace Silt, dry. Concerete pieces are encountered at the tip of the spoon.	FILL		
5	S2	24/0	5.5 - 7.5	3 7 3 6	S2: No recovery. **Note:** Bedrock encountered at 9.3 ft bgs. Coring started at 9.3 ft bgs.	URBAN FILL		
10	C1	60/60	9.3 - 14.3	-	C1: Gray, fine-grained, WACKE and ARENITE, moderately hard, slightly to moderately weathered, 3.0 fractures per foot (RQD: 40%; Poor) [Cookson Group]. Rock Coring Rate (min:sec) 9.3 - 10.3 ft: 04:22 10.3 - 11.3 ft: 03:57 11.3 - 12.3 ft: 04:30 12.3 - 13.3 ft: 05:03 13.3 - 14.3 ft: 05:32	BEDROCK		
15	C2	23/23	14.3 - 16.2	-	C2: Gray, fine-grained, WACKE and ARENITE, moderately hard, slightly to moderately weathered, 2.6 fractures per foot (RQD: 0%; Very Poor. [Cookson Group]. Rock Coring Rate (min:sec) 14.3 - 15.3 ft: 05:35 15.3 - 16.2 ft: 05:51			
	C3	37/37	16.2 - 19.3	-	C3: Gray, fine-grained,WACKE and ARENITE, moderately hard, slightly to moderately weathered, 2.9 fractures per foot (RQD: 65%; Fair) [Cookson Group].			
20					Boring terminated at 19.3 ft bgs.			

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	Density	Blows/ft.	Consistency
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring Terminated at 19.3 ft bgs. Boring backfilled with cuttings to ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface
* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be correlated to standard N-values

SOIL BORING LOG

verdantas

Client: Maine Department of Marine Resources	**Boring Identification: B-4**	
Project: Woodland Fish Passage Design		**Sheet:** 1 of 1
Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** CJS	**Project Number:** 16667
Drilling Company: New England Boring Company	**Boring Location Lat/Long:** 45.15845772°/ -67.40148536°	
Foreman: Tom	**Ground Surface Elevation:** 109'	**Datum:** NAVD88
Engineer/Geologist: Joel Morin	**Date Started:** 4/5/24	**Date Completed:** 4/5/24

DRILLING METHOD	SAMPLER
Vehicle: ATV	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: SSA/Driven casing/rock hammer	**Fall (in):** ~18*

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
04/05/2024	Not observed	Ground Surface	During Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0–10					**Note:** Solid Stem auger through 10 ft of loose silty SAND, laden with boulders.	FILL		
10					Boring terminated at 10 bgs.			
11–20								

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	**Density**	**Blows/ft.**	**Consistency**
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring backfilled with cuttings to the ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface
* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be corelated to standard N-values

SOIL BORING LOG

verdantas PEOPLE FOCUSED FUTURE

Client: Maine Department of Marine Resources	**Boring Identification: B-6**	
Project: Woodland Fish Passage Design		**Sheet:** 1 of 1
Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** CJS	**Project Number:** 16667
Drilling Company: New England Boring Company	**Boring Location Lat/Long:** 45.15866249˚/ -67.40183773˚	
Foreman: Tom	**Ground Surface Elevation:** 112'	**Datum:** NAVD88
Engineer/Geologist: Joel Morin	**Date Started:** 4/4/24	**Date Completed:** 4/5/24

DRILLING METHOD	SAMPLER
Vehicle: ATV	**Type:** SS 2" - NQ Core
Model: Soil Scout	**Hammer (lb):** 140
Method: SSA/Driven casing/rock hammer	**Fall (in):** ~18

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
04/05/2024	Not observed	Ground Surface	During Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0–5					**Note:** Solid stem auger to 5 ft bgs; casing driven to 5 ft bgs.	FILL		
5–11					**Note:** Weathered and highy fractured bedrock encountered at 8.1 ft bgs. Attempted air hammer initially; replaced by rolller bit and flowing water to 11 ft bgs.	HIGHLY FRACTURED BEDROCK		
11–16	C1	60/56	11-16	-	**Note:** Bedrock encountered at 11 ft bgs. Coring started at 11 ft bgs. C1: Gray/light gray, fine to coarse grained, interbedded WACKE and thinly laminated ARENITE, Several core barrel jams, and starting and stopping to clear jams [Cookson Group]. Recovery: 93% RQD: 65%. Rock Coring Rate (min:sec) 11 - 12 ft 2:54; 12 - 13 ft 4:36; 13 - 14 ft 3:51; 14 - 15 ft 5:12; 15 - 16 ft 7:01	BEDROCK		
16–20					Boring terminated at 16 ft bgs.			

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	Density	Blows/ft.	Consistency
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring backfilled with cuttings to the ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs = below the ground surface

* Short and inconsistent hammer drop height using rope and cathead with donut hammer; cannot be corelated to standard N-values

SOIL BORING LOG

verdantas PEOPLE FOCUSED FUTURE

Client: Maine Department of Marine Resources	**Boring Identification:** B-8
Project: Woodland Fish Passage Design	**Sheet:** 1 of 1
Location: Woodland Dam, St. Croix River, Baileyville, Maine	**Checked By:** **Project Number:** 16667
Drilling Company: New England Boring Contractors	**Boring Location Lat/Long:** 45.15793977˚/ -67.40089266˚
Foreman: Devon Share	**Ground Surface Elevation:** 108' **Datum:** NAVD88
Verdantas Engineer/Geologist: Begum Kurtoglu	**Date Started:** 11/10/2023 **Date Completed:** 11/10/2023

DRILLING METHOD	SAMPLER
Vehicle: Drill 28	**Type:** SS 2" - NQ Core
Model: B53	**Hammer (lb):** 140
Method: Drive and Wash 3"	**Fall (in):** 30

GROUNDWATER MEASUREMENTS

Date	Depth (ft)	Reference	Stabilization
11/10/2023	5.8	Ground Surface	After Drilling

DEPTH (ft)	#	Pen/Rec (in)	Depth (ft)	Blows/6"	SAMPLE DESCRIPTION	STRATUM DESCRIPTION	FIELD SCREENING (ppm)	NOTE
0					Note: Hand excavated to 2.1 ft below ground surface to confirm no utilities present at boring location.			
1								
2	S1	6/0	2.1 - 2.6	21	S1: No recovery.			
				50/0"				
3				-		FILL		
				-				
4	S2	22/5	4.0 - 5.9	4	S2: Loose, gray, GRAVEL and fine to coarse SAND, some Rock Pieces, trace Silt, dry.			
				4				
5				5				
				50/4"	**Note:** Weathered bedrock encountered starting from 5.8 ft to 6.3 ft bgs. Coring started at 6.3 ft bgs.	WEATHERED BEDROCK		
6								
7	C1	60/60	6.3 - 11.3	-	C1: Gray, fine-grained, WACKE and ARENITE, moderately hard, moderately to highly weathered, 5.4 fractures per foot (RQD: 0%; Very poor) [Cookson Group]. Rock Coring Rate (min:sec) 6.3 - 7.3 ft: 01:38 7.3 - 8.3 ft: 01:51 8.3 - 9.3 ft: 01:39 9.3 - 10.3 ft: 01:41 10.3 - 11.3 ft: 01:56	BEDROCK		
8								
9								
10								
11					Boring terminated at 11.3 ft bgs.			
12								
13								
14								
15								
16								
17								
18								
19								
20								

GRANULAR SOILS		COHESIVE SOILS	
Blows/ft.	**Density**	**Blows/ft.**	**Consistency**
0-4	V. LOOSE	<2	V. SOFT
5-10	LOOSE	2-4	SOFT
11-30	M. DENSE	4-8	M. STIFF
31-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		>30	HARD

NOTES

1. Boring backfilled with cuttings to the ground surface.
2. Ground surface elevation approximated based on Existing Conditions Plan dated 4/10/2023.
3. Lat/Long coordinates approximated from Google Earth.

bgs= below ground surface

Appendix B

GPRS Report

JOB SUMMARY

Service Completed Date: 09/27/2023

Customer: VERDANTAS LLC

Phone Number:

Billing Address	City	State	Zip
5400 LIMESTONE ROAD	WILMINGTON	DE	19808

Job Details

Jobsite Location	City	State	Zip
144 Main St,	Baileyville	ME	04694

Work Order Number	592862-96751	**Customer Service Phone Num**	
Job Num	15866	**PO Num**	15866

Project Manager: Michael Russett

Email: Michael.Russett@gprsinc.com

Thank you for using GPRS on your project. We appreciate the opportunity to work with you. If you have questions regarding the results of this scanning, please contact the lead GPRS technician on this project.

EQUIPMENT USED

The following equipment was used on this project:

- **Underground GPR Antenna:** This GPR Antenna uses frequencies ranging from 250 MHz to 450 MHz and is mounted in a stroller frame that rolls over the surface. Data is displayed on a screen and marked in the field in real-time. The surface needs to be reasonably smooth and unobstructed to obtain readable scans. Obstructions such as curbs, landscaping, and vegetation will limit the efficacy of GPR. The total effective scan depth can be as much as 8’ or more with this antenna but can vary widely depending on the soil conditions and composition. Some soil types, such as clay, may limit maximum depths to 3’ or less. As depth increases, targets must be larger to be detected, and non-metallic targets can be challenging to locate. The depths provided should always be treated as estimates as their accuracy can be affected by multiple factors. For more information, please visit: Link
- **EM Pipe Locator:** Electromagnetic Pipe and Cable Locator. Detects electromagnetic fields. Used to actively trace conductive pipes and tracer wires, or passively detect power and radio signals traveling along conductive pipes and utilities. For more information, please visit: Link
- **GPS:** This handheld unit offers accuracy down to 4 inches; however, the accuracy achieved will depend on the satellite environment at the time of collection and is not considered survey-grade. Features can be collected as points, lines, or areas and then exported as a KML/KMZ or overlaid on a CAD drawing. For more information, please visit: Link

JOB SUMMARY

WORK PERFORMED
GPRS performed the following work on this project:

UNDERGROUND UTILITY

- A total of 8 boring locations were scanned.
- The effective depth of GPR will vary throughout a site depending on a variety of factors such as surface type, surface conditions, soil type, and moisture content. At this site, the maximum effective GPR depth was approximately 2-3 feet.

RESULTS AND NOTES

Details on Unlocatable Utilities	2 catch basins filled with dirt, 1 catch basin filled with water.
Limitations Encountered	Surface Obstructions, Surface to rough, RF Interference
Obstructions Encountered	Heavy vegetation, concrete curbs, fence, and above ground pipes.
Additional Notes	A total of 8 locations were scanned in an approximately 10ft radius for all locatable utilities and anomalies. B-7 was not scanned due to restricted access. Additional location was added and scanned in proximity to B-8. Each of the locations were thoroughly scanned in a grid pattern utilizing GPR as well as “radio” and “power” modes with electromagnetic locator. Unknown pipes located in proximity to B-1 utilized GPR and observed at a depth of <1ft to 3ft below surface. Unknown lines marked in pink marking paint and flags. Scan areas marked in white marking paint. Two storm catch basins filled with dirt and one storm catch basin filled with water, could not identify directions of pipes. Recommend digging with caution within 1ft of any marked line or obstruction. GPR effectiveness may have been inhibited by contents of soil/gravel. Electromagnetic locator effectiveness may have been inhibited by proximity to high energy equipment and electromagnetic fields.

Unlocatable Utility Types:	Storm Sewer	Located Utilities:	Unknown
Client performed 811 Location Request:	No	Marking Medium:	Spray Paint, Flags
		Client Provided Drawings:	Yes
Findings Walkthrough done with client:	Yes		
Client's Scope of Work:	Soil boring		

JOB SUMMARY

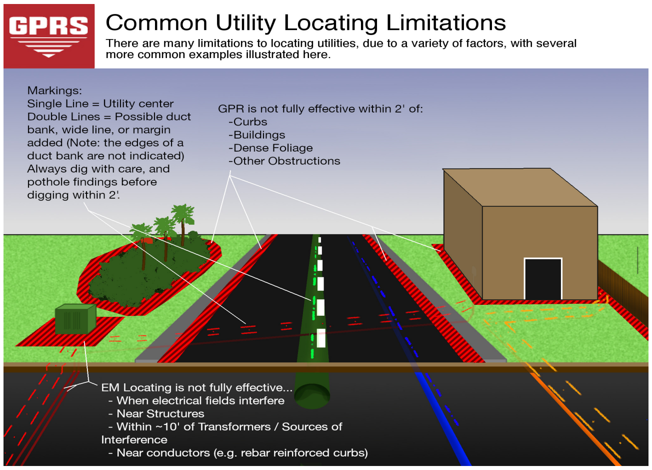
Image 1

Image 2

Image 3

Image 4

JOB SUMMARY



CONTACT / SIGNATURE INFORMATION

TERMS & CONDITIONS

http://www.gprsinc.com/termsandconditions.html

SIGNATURE

CONTACT NAME

BEGUM KURTOGLU 573-808-1513


GPRS
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BUILD AT THE SPEED OF INSIGHT
GPRS DELIVERS SINGULAR SOLUTIONS IN 3D TECHNOLOGY
GPRS Intelligently Visualizes The Built World™ above and below ground as the leading provider of accurate and creative 3D laser scanning solutions for the construction, architecture, and engineering industries.
3D laser scan technology is a cost-effective solution to your facility visualization needs. It can reduce and even eliminate costly errors to speed up your design, engineering, and construction process.
ABOVE AND BELOW GROUND DATA CAPTURE
The combination of laser scanning and ground penetrating radar allows you to visualize your facility effectively and accurately.
Our fully integrated service gives you accurate data to expedite design planning, extract 3D coordinates and measure distances, along with the ability to mark-up and share this with project teams. Receiving critical site information will lower project risks and increase project efficiency.
What can GPRS help you visualize?
SERVICES
SUBSURFACE INVESTIGATION METHODOLOGY SIM
TRAINING
EQUIPMENT
METHODOLOGY
The use of proper training, multiple technologies and a field-tested methodology are the key to a successful utility locate. GPRS is a master of all three components through the utilization of the SIM Specification.
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UTILITY LOCATING
VIDEO PIPE INSPECTION
LEAK DETECTION
MAPPING & MODELING
CONCRETE IMAGING
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GPRSINC.COM

Appendix C

Design Calculations

verdantas **CALCULATIONS**

Date:	7/30/2024	**Prepared by:**	LTV	7/30/2024
Project No.:	16667	**Reviewed by:**	CJVH	11/7/2024
Subject:	Bearing Capacity of Rock	**Checked by:**	MCP	11/21/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

The purpose of this sheet is to provide justification for the values used in determining the bearing capacity of rock. Three separate methods for determining the bearing capacity were considered, and a reasonable value was determined based upon the results of all three.

A total of 11 rock cores were taken from the site, with RQD's ranging from 0% to 66%. The rock comes from the Woodland Formation, part of the Cookson Group, consisting of wacke and shale. Overall, the rock appeared fractured to very fractured but competent.

References:

1. US Army Corps of Engineers (1994). "Manual No. 1110-1-2908 (Engineering and Design - Rock Foundations)", Department of the Army, Washington DC.
2. Sabatini et. al. (2002). "Geotechnical Engineering Circular No. 5 (Evaluation of Soil and Rock Properties)", Federal Highway Administration, Washington DC.
3. NAVFAC (1982). "Design Manual 7.2 (Foundations and Earth Structures)", US Navy
4. Lindeburg (2014). "Civil Engineering Reference Manual (14th Edition)", Professional Publication Inc.

Assumptions:

1. When preparing subgrade for foundations on rock, highly weathered and unsuitable rock, and/or fractured rock with loose pieces, will be removed until a more competent rock surface is reached.
2. Rock is considered to be submerged.

Calculations:

Method 1: Empirical correlation between allowable bearing capacity and RQD (from Peck, Hanson, and Thornburn 1974)

The first method used to consider bearing capacity of the variable layered rock observed in the study areas indicated highly variable results. Therefore, Verdantas used a conservative design approach for structures bearing directly on rock.

An empirical correlation between allowable bearing capacity stress and RQD is shown in Figure 6.6. (Reference 1)

The RQD of cores recovered was generally between 0 and 60%. Using the figure to the right, the allowable bearing is as follows.

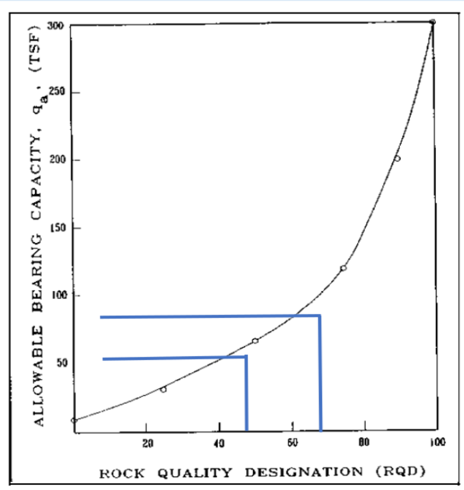

Figure 6-6. Allowable contact pressure on jointed rock

RQD (%)	Allowable Bearing (tsf)
0	9
40	55
60	85

9 tsf

Method 2: Presumptive Values of Allowable Bearing Pressures for Spread Foundations

Table 1 - Reference 3

A second method of evaluation considers the rock type and consistency utilizing Table 1 of Reference 3, to arrive at presumptive allowable bearing pressurevalues

Cores were described as weathered or broken bedrock. Therefore, the rock was considered to meet the definition of weatherer or broken rock. The allowable range for this type of rock in place is 8-12 tsf. We selected the midpoint of this range to arrive at a recommended value of 10 tsf.

Allowable bearing pressure 8 to 12 tsf

10 tsf

TABLE 1

Presumptive Values of Allowable Bearing Pressures for Spread Foundations

Type of Bearing Material	Consistency In Place	Allowable Bearing Pressure Tons Per sq ft Range	Recommended Value for Use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks).	Hard, sound rock	60 to 100	80.0
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks).	Medium hard sound rock	30 to 40	35.0
Sedimentary rock; hard cemented shales, siltstone, sandstone, limestone without cavities.	Medium hard sound rock	15 to 25	20.0
Weathered or broken bed rock of any kind except highly argillaceous rock (shale). RQD less than 25.	Soft rock	8 to 12	10.0
Compaction shale or other highly argillaceous rock in sound condition.	Soft rock	8 to 12	10.0
Well graded mixture of fine and coarse-grained soil: glacial till, hardpan, boulder clay (GW-GC, GC, SC)	Very compact	8 to 12	10.0
Gravel, gravel-sand mixtures, boulder gravel mixtures (SW, SP, SW, SP)	Very compact Medium to compact Loose	6 to 10 4 to 7 2 to 6	7.0 5.0 3.0
Coarse to medium sand, sand with little gravel (SW, SP)	Very compact Medium to compact Loose	4 to 6 2 to 4 1 to 3	4.0 3.0 1.5
Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC)	Very compact Medium to compact Loose	3 to 5 2 to 4 1 to 2	3.0 2.5 1.5

Method 3: FHA Recommended Allowable Bearing Pressure for Footings on Rock

Table 35.18 from Reference 4

A third method of evaluation considers the rock type utilizing FHA Recommended Allowable Bearing Pressure for Footings on Rock (Reference 4.)

Cores were described at weathered or broken sedimentary bedrock.

We selected a value based upon the recommended capacity for sedimentary rocks, including hard shale and sandstone, with less than 50% RQD.

Allowable bearing for footings on Rock of Hard shale with less than 50% RQD:

8 tsf

material and RQD	allowable contact pressure (tsf (kPa))
igneous and sedimentary rock, including crystalline bedrock, including granite, diorite, gneiss, and traprock; hard limestone and dolomite*	
75–100%	120 (11 491)
50–75%	65 (6224)
25–50%	30 (2873)
< 25%	10 (958)
metamorphic rock, including foliated rocks (e.g., schist and slate); bedded limestone*	
> 50%	40 (3830)
< 50%	10 (958)
sedimentary rocks, including hard shale and sandstone*	
> 50%	25 (2394)
< 50%	10 (958)
soft or broken bedrock (excluding shale); soft limestone*	
> 50%	12 (1149)
< 50%	8 (766)
soft shale	4 (383)

(Multiply tsf by 95.8 to obtain kPa.)
*in sound condition

Source: Federal Highway Administration memorandum, July 19 1991, from Stanley Gordon, FHA Bridge Division Chief, to Regional Federal Highway Administrators.

Conclusion:

The quality and characteristics of bedrock core samples collected at the site varied. We arrived at three conservative bearing capacity values via the methods described above and recommend using 8 tsf as the low end finding of the three methods, which ranged from 8 tsf to 10 tsf.

Bearing Capacity of Bedrock 8 tsf

verdantas

CALCULATIONS

Date:	12/9/2024	**Prepared by:**	CJS	12/9/2024
Project No.:	16667	**Checked by:**	CJVH	12/10/2024
Subject:	Micropile Calculation - Fish Ladder	**Reviewed by:**	MCP	12/10/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:
Verdantas performed a calculation to assess micropile response to combined compression and lateral loading at the proposed fish lift foundation location using the LPile software package. The aim of the assessment is to identify critical micropile loading condition (i.e., generating the maximum bending moment on the pile below the ground surface), depth to negligible lateral forces on the pile (to determine bottom of casing length), and estimated pile head deflection. This calculation narrative documents assumptions and input parameters used in this analysis.

References:
1. Sabatini et. al. (2005). "Micropile Design and Construction (Reference Manual for NHI Course 132078)," National Highway Institute, Washington D.C.
2. Software Package: LPile 2019.11.09 by Ensoft, Inc.
3. FB-MultiPier Soil Parameter Table (US Customary Units). Bridge Software Institute.

Assumptions:
1. Micropiles are adequately spaced such that there are not group effects (i.e., at least 30 inches or 3 micropile diameters, whichever is greater).
2. Assume initial casing has a 7 inch outside diameter, 0.5 inch casing wall thickness, and steel with 80ksi yield stress. There is little known about the Site's corrosion potential, so it is assumed that the Site will have aggressive ground conditions. Therefore, 0.063 inches of steel loss is conservatively assumed (per Reference 1) on the outside of the casing during the design life, reducing the outside casing diameter to 6.87 inches and wall thickness to 0.44 inch.
3. Analyze only the cased section, as it will be designed to carry the lateral and moment loading. The uncased pile length will be located below the depth to zero bending moment, as the uncased length performs poorly in bending.

Calculation:
The following section documents the input parameters used in the LPile software. The software package has three primary input menus: Pile Properties, Soil Properties, and Pile Head Loading.

Pile Properties Menu

Model pile (**described in assumption 2**) as a round shaft with casing and a core/insert (#10 threadbar). No rebar cage reinforcement is used. The material properties used in this analysis are selected based on preliminary analyses as this calculation is an iterative process with multiple LPile analyses and subsequent geo/structural capacity checks.

Length of Section =	15	feet	(assumed to be long enough to extend through the overburden and into competent rock)
Casing Outside Diameter =	6.874	inches	(with corrosion reduction as stated in Assumption 2)
Casing Wall Thickness =	0.437	inches	(with corrosion reduction as stated in Assumption 2)
Core (Threadbar) Diameter =	1.43	inches	(#10 threadbar, selected based on preliminary analyses)
Core (Threadbar) Wall Thickness =	0.715	inch	(solid bar, half diameter of #10 threadbar, selected based on preliminary analyses)
Compressive Strength of Grout/Concrete =	4,000	psi	(assumed, typical for micropile design and construction)
Max. Coarse Aggregate Size =	0.75	in	(assumed, typical for micropile design and construction)
Yield Stress of Casing =	80,000	psi	(assumed, typical for micropile design and construction)
Elastic Modulus of Casing =	29,000,000	psi	(assumed, typical for micropile design and construction)
Yield Stress of Core/Insert =	75,000	psi	(assumed, typical for micropile design and construction)
Elastic Modulus of Casing =	29,000,000	psi	(assumed, typical for micropile design and construction)
Core/Insert Type =	Steel Pipe Section		

Soil Properties Menu

Define soil acting along the side of micropile in two layers: Layer 1 = Fill and Layer 2 = Bedrock. The subgrade materials are modeled in the LPile software using p-y curves which predict lateral pile response to loading. The software requires that input properties be provided for the top and bottom of soil layer to account for linear variation of properties within the layer; however, this analysis assumes material properties are consistent throughout the layer. Input properties for each of the layers are as follow:

Layer 1 - Fill

The overburden soils at the site are interpreted be fill consisting of silty sand and gravel with cobble/boulders and concrete rubble. Based on the drilling logs, it does not appear that there are appreciable voids within the fill (i.e. sudden drops of the drill string/sampling tools) and as such, from a lateral pile response perspective, we have model the layer as a granular sand/gravel fill.

p-y Curve Type =	API Sand (O'Neill)		(this model was selected as it is applicable for pipe piles in sand)
Vertical Depth Below Pile Head of Top of Soil Layer =	0	feet	(assumed, pile starts at the existing ground surface)
Top of Layer Effective Unit Weight =	125	pcf	(assumed, for a loose gravelly sand)
Top of Layer Friction Angle =	34	degrees	(assumed, for a loose gravelly sand)
Top of Layer k_1 =	Program default	pci	(the program will take the input parameters to determine the k1 value)
Vertical Depth Below Pile Head of Bottom of Soil Layer =	10	feet	(assumed, fill extends to the top of competent rock surface)
Bottom of Layer Effective Unit Weight =	125	pcf	(assumed, for a loose gravelly sand)
Bottom of Layer Friction Angle =	34	degrees	(assumed, for a loose gravelly sand)
Bottom of Layer k_1 =	Program default	pci	(the program will take the input parameters to determine the k1 value)

Layer 2 - Bedrock

Based on preliminary analyses, the bending moments within the pile occur above the bedrock surface and the bedrock does not play much of a role in the analysis. The rock itself is interpreted to be moderately strong but highly fractured; therefore, the bedrock is conservatively modeled as being weak, but providing more resistance that the overlying fill. The water table is interpreted to be at the approximate top of rock surface.

p-y Curve Type =	Weak Rock (Reese)		(this model was selected to simulate lateral pile response in weak rock)
Vertical Depth Below Pile Head of Top of Rock Layer =	10	feet	(assumed, top of competent rock surface)
Top of Layer Effective Unit Weight =	79.6	pcf	(assumed, conservatively lightweight rock below the water table)
Top of Layer Strain factor (krm) =	0.0005		LPile user manual states value typically ranges from 0.0005 to 0.00005. The selected end of the range provides a negligibly larger bending moment and was selected for design.
Top of Layer Uniaxial Compressive Strength (qu) =	100	psi	(assumed, conservatively very low strength rock)
Top of Layer Initial Modulus of Rock Mass =	106500	psi	(Reference 3, for sandstone)
RQD =	10	%	(low end range of rock quality. Measured RQD in the field was 0-66%, but generally on the low end of the range)
Vertical Depth Below Pile Head of Bottom of Rock Layer =	50	feet	(assumed, extent of rock conservatively longer than what is needed for the model)
Top of Layer Effective Unit Weight =	79.6	pcf	(assumed, conservatively lightweight rock below the water table)
Top of Layer Strain factor (krm) =	0.0005		Lpile user manual states value typically ranges from 0.0005 to 0.00005. The selected end of the range provides a negligibly larger bending moment and was selected for design.
Top of Layer Uniaxial Compressive Strength (qu) =	100	psi	(assumed, conservatively very low strength rock)
Top of Layer Initial Modulus of Rock Mass =	106500	psi	(Reference 3, for sandstone)
RQD =	10	%	(low end range of rock quality. Measured RQD in the field was 0-66%, but generally on the low end of the range)

Pile-Head Loading

Structural evaluation assumed pinned head condition. Per the LPILE software package, to specify a pinned-head condition, the shear and moment loading condition should be selected and the moment value should be set equal to zero. The following loading conditions were selected from the structural analysis.

Case 1: Maximum Lateral Loading

Shear Force =	10,590	pounds
Moment Force =	0	inch-pounds
Axial Load =	65,485	pounds (tension)

Case 2: Maximum Axial Loading Condition

Shear Force =	6,300	pounds
Moment Force =	0	inch-pounds
Axial Load =	75,639	pounds (compression)

Case 3: Maximum Tensile Load

Shear Force =	4,480	pounds
Moment Force =	0	inch-pounds
Axial Load =	-27,517	pounds (tension)

Model Output:

Case 1: Maximum Lateral Loading

Pile Head Deflection =	0.97	inch
Maximum Bending Moment =	446,151	inch-pounds, @ 4.5 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	12.75	feet

Case 2: Maximum Axial Loading Condition

Pile Head Deflection =	0.37	inch
Maximum Bending Moment =	212,476	inch-pounds, @ 3.75 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	12	feet

Case 3: Maximum Tensile Load

Pile Head Deflection =	0.20	inch
Maximum Bending Moment =	114,604	inch-pounds, @ 3.3feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	11.3	feet

Conclusion:

Based on the results of the loading cases analyzed, Case 1 has the largest bending moment and will control the buckling portion of the design. However, the maximum compression and tension loads will be used to design the uncased bond lengths.

===

LPile for Windows, Version 2019-11.009

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

===

This copy of LPile is being used by:

GeoInsight Inc.
Manchester, NH

Serial Number of Security Device: 562557655

This copy of LPile is licensed for exclusive use by:

GeoInsight, Inc., Manchester, NH

Files Used for Analysis

Path to file locations:
\Project Files\MA-NZ\MEDMR\16667 - Woodland Fish Lift Design\Working\Geotechnical Investigation\Design\LPile Design\

Name of input data file:
dec24 loads Woodland Micropile max comp max shear_corrosion.lp11d

Name of output report file:
dec24 loads Woodland Micropile max comp max shear_corrosion.lp11o

Name of plot output file:
dec24 loads Woodland Micropile max comp max shear_corrosion.lp11p

Name of runtime message file:
dec24 loads Woodland Micropile max comp max shear_corrosion.lp11r

----

Date and Time of Analysis

Date: December 18, 2024   Time: 11:12:40

Problem Title

Project Name: Woodland Fish Passage Design

Job Number: 16667

Client: State of Maine; Marine Resources, Bureau of Sea Run Fisheries

Engineer: Cameron J. Stuart PE

Description: Micropile Calculation - Fish Ladder

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

```
Number of pile sections defined                          =            1
Total length of pile                                     =       15.000 ft
Depth of ground surface below top of pile                =       0.0000 ft
```

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	6.8740
2	15.000	6.8740

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a drilled shaft with casing and pipe core
   Length of section                                     =    15.000000 ft
```

```
   Section Diameter                                       =     6.874000 in
   Shear capacity of section                              =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by API RP-2A, 1987

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =    10.000000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 pcf
   Friction angle at top of layer                         =    34.000000 deg.
   Friction angle at bottom of layer                      =    34.000000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer              =    10.000000 ft
   Distance from top of pile to bottom of layer           =    50.000000 ft
   Effective unit weight at top of layer                  =    79.600000 pcf
   Effective unit weight at bottom of layer               =    79.600000 pcf
   Uniaxial compressive strength at top of layer          =   100.000000 psi
   Uniaxial compressive strength at bottom of layer       =   100.000000 psi
   Initial modulus of rock at top of layer                =      106500. psi
   Initial modulus of rock at bottom of layer             =      106500. psi
   RQD of rock at top of layer                            =    10.000000 %
   RQD of rock at bottom of layer                         =    10.000000 %
   k rm of rock at top of layer                           =    0.0005000
   k rm of rock at bottom of layer                        =    0.0005000
```

(Depth of the lowest soil layer extends 35.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	API	0.00	125.0000	34.0000	--	--	--	default	--
	Sand	10.0000	125.0000	34.0000	--	--	--	default	--
2	Weak	10.0000	79.6000	--	100.0000	10.0000	5.00E-04	--	106500.
	Rock	50.0000	79.6000	--	100.0000	10.0000	5.00E-04	--	106500.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 10590. lbs	M = 0.0000 in-lbs	65485.	No	Yes

```
   2     3     V =        6300. lbs   R =       0.0000 in-lbs           75639.
    No                Yes
   3     1     V =        4480. lbs   M =       0.0000 in-lbs          -27517.
    No                Yes
```

```
V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.
```

```
--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and Pipe Core:
------------------------------------------------------------------------------------

Length of Section                                      =    15.000000 ft
Outside Diameter of Casing                             =     6.874000 in
Casing Wall Thickness                                  =     0.437000 in
Moment of Inertia of Steel Casing                      =    45.982107 in^4
Outside Diameter of Core                               =     1.430000 in
Core Wall Thickness                                    =     0.715000 in
Moment of Inertia of Steel Core/Insert                 =     0.205265 in^4
Yield Stress of Casing                                 =       80000. psi
Elastic Modulus of Casing                              =    29000000. psi
Yield Stress of Core/Insert                            =       75000. psi
Elastic Modulus of Core/Insert                         =    29000000. psi
Number of Reinforcing Bars                             =            0 bars
Gross Area of Pile                                     =    37.111537 sq. in.
Area of Concrete                                       =    26.668273 sq. in.
Cross-sectional Area of Steel Casing                   =     8.837203 sq. in.
Cross-sectional Area of Steel Core/Insert              =     1.606061 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)      =    10.443263 sq. in.
Area Ratio of All Steel to Gross Area                  =        28.14 percent

Note that the core is assumed to be void of concrete.
```

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	918.103 kips
Tensile Load for Cracking of Concrete	=	-46.032 kips
Nominal Axial Tensile Capacity	=	-827.431 kips

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

Number	Axial Thrust Force kips
1	-27.517
2	65.485
3	75.639

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = -27.517 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000125	1.9987340	1598987.	-49.7404666	-0.00006218	-0.00007077	-0.2595276	0.00000	-2.0510285	-1.9538473	
0.00000250	3.9974678	1598987.	-23.1520578	-0.00005788	-0.00007507	-0.2420666	0.00000	-2.1743974	-1.9800350	
0.00000375	5.9962009	1598987.	-14.2893991	-0.00005359	-0.00007936	-0.2245673	0.00000	-2.2977819	-2.0062384	
0.00000500	7.9949332	1598987.	-9.8581779	-0.00004929	-0.00008366	-0.2070295	0.00000	-2.4211820	-2.0324573	
0.00000625	9.9936643	1598986.	-7.1995318	-0.00004500	-0.00008796	-0.1894533	0.00000	-2.5445979	-2.0586920	
0.00000750	11.9923940	1598986.	-5.4271731	-0.00004070	-0.00009226	-0.1718388	0.00000	-2.6680295	-2.0849425	
0.00000875	13.9911220	1598985.	-4.1612644	-0.00003641	-0.00009656	-0.1541859	0.00000	-2.7914768	-2.1112086	
0.00001000	15.9898479	1598985.	-3.2118870	-0.00003212	-0.0001009	-0.1364946	0.00000	-2.9149398	-2.1374904	
0.00001125	17.9885715	1598984.	-2.4735305	-0.00002783	-0.0001052	-0.1187650	0.00000	-3.0384185	-2.1637879	
0.00001250	19.9872925	1598983.	-1.8828885	-0.00002354	-0.0001095	-0.1009971	0.00000	-3.1619128	-2.1901011	
0.00001375	21.9860106	1598983.	-1.3996753	-0.00001925	-0.0001138	-0.0831908	0.00000	-3.2854229	-2.2164299	
0.00001500	21.9860106	1465734.	-2.6202513	-0.00003930	-0.0001424	0.00000	0.00000	-4.1150483	-2.9488742	C
0.00001625	21.9860106	1352985.	-2.1543089	-0.00003501	-0.0001467	0.00000	0.00000	-4.2383937	-2.9750384	C
0.00001750	23.4408281	1339476.	-1.7549297	-0.00003071	-0.0001510	0.00000	0.00000	-4.3617390	-3.0012026	C
0.00001875	25.1151730	1339476.	-1.4088011	-0.00002642	-0.0001553	0.00000	0.00000	-4.4850843	-3.0273667	C
0.00002000	26.7895179	1339476.	-1.1059385	-0.00002212	-0.0001596	0.00000	0.00000	-4.6084297	-3.0535309	C
0.00002125	28.4638627	1339476.	-0.8387068	-0.00001782	-0.0001639	0.00000	0.00000	-4.7317750	-3.0796950	C
0.00002250	30.1382076	1339476.	-0.6011675	-0.00001353	-0.0001682	0.00000	0.00000	-4.8551203	-3.1058592	C
0.00002375	31.8125525	1339476.	-0.3886324	-0.00000923	-0.0001725	0.00000	0.00000	-4.9784657	-3.1320233	C
0.00002500	33.4868973	1339476.	-0.1973508	-0.00000493	-0.0001768	0.00000	0.00000	-5.1018110	-3.1581875	C
0.00002625	35.1612422	1339476.	-0.0242865	-6.37520E-07	-0.0001811	0.00000	0.00000	-5.2251563	-3.1843517	C

```
0.00002750    36.8355871    1339476.    0.1330447    0.00000366    -0.0001854
0.0115004     0.00000      -5.3485017   -3.2105158 C
0.00002875    38.5099319    1339476.    0.2766950    0.00000795    -0.0001897
0.0294930     0.00000      -5.4718470   -3.2366800 C
0.00003000    40.1842768    1339476.    0.4083743    0.00001225    -0.0001940
0.0474450     0.00000      -5.5951923   -3.2628441 C
0.00003125    41.8601132    1339524.    0.5294662    0.00001655    -0.0001983
0.0653493     0.00000      -5.7185858   -3.2890564 C
0.00003250    43.5429138    1339782.    0.6409992    0.00002083    -0.0002026
0.0831796     0.00000      -5.8422095   -3.3154989 C
0.00003375    45.2353643    1340307.    0.7439321    0.00002511    -0.0002069
0.1009217     0.00000      -5.9661642   -3.3422725 C
0.00003500    46.9374100    1341069.    0.8391764    0.00002937    -0.0002112
0.1185743     0.00000      -6.0904603   -3.3693874 C
0.00003625    48.6484273    1342026.    0.9275379    0.00003362    -0.0002156
0.1361394     0.00000      -6.2150868   -3.3968327 C
0.00003750    50.3694117    1343184.    1.0096585    0.00003786    -0.0002199
0.1536100     0.00000      -6.3400939   -3.4246587 C
0.00003875    52.0984361    1344476.    1.0861974    0.00004209    -0.0002243
0.1709954     0.00000      -6.4654197   -3.4528033 C
0.00004000    53.8349047    1345873.    1.1576901    0.00004631    -0.0002287
0.1882980     0.00000      -6.5910501   -3.4812525 C
0.00004125    55.5781844    1347350.    1.2246095    0.00005052    -0.0002330
0.2055205     0.00000      -6.7169682   -3.5099894 C
0.00004250    57.3275936    1348885.    1.2873759    0.00005471    -0.0002374
0.2226660     0.00000      -6.8431530   -3.5389931 C
0.00004375    59.0824250    1350455.    1.3463643    0.00005890    -0.0002418
0.2397382     0.00000      -6.9695807   -3.5682396 C
0.00004500    60.8427805    1352062.    1.4018802    0.00006308    -0.0002462
0.2567358     0.00000      -7.0962634   -3.5977411 C
0.00004625    62.6081988    1353691.    1.4542146    0.00006726    -0.0002507
0.2736606     0.00000      -7.2231883   -3.6274849 C
0.00004750    64.3773048    1355312.    1.5036624    0.00007142    -0.0002551
0.2905214     0.00000      -7.3502953   -3.6574106 C
0.00004875    66.1494051    1356911.    1.5504682    0.00007559    -0.0002595
0.3073229     0.00000      -7.4775524   -3.6874866 C
0.00005125    69.7056116    1360109.    1.6368090    0.00008389    -0.0002684
0.3407240     0.00000      -7.7326926   -3.7482644 C
0.00005375    73.2724902    1363209.    1.7147423    0.00009217    -0.0002773
0.3738917     0.00000      -7.9884185   -3.8096280 C
0.00005625    76.8484524    1366195.    1.7854268     0.0001004    -0.0002862
0.4068358     0.00000      -8.2446688   -3.8715159 C
0.00005875    80.4319815    1369055.    1.8498258     0.0001087    -0.0002952
0.4395660     0.00000      -8.5013787   -3.9338635 C
0.00006125    84.0216509    1371782.    1.9087468     0.0001169    -0.0003041
0.4720927     0.00000      -8.7584811   -3.9966035 C
0.00006375    87.6161395    1374371.    1.9628718     0.0001251    -0.0003131
0.5044259     0.00000      -9.0159065   -4.0596665 C
0.00006625    91.2161783    1376848.    2.0127099     0.0001333    -0.0003221
0.5365574     0.00000      -9.2737200   -4.1231178 C
```

0.00006875	94.8196752	1379195.	2.0587914	0.0001415	-0.0003310
0.5685050	0.00000	-9.5317968	-4.1868322 C		
0.00007125	98.4250904	1381405.	2.1015631	0.0001497	-0.0003400
0.6002833	0.00000	-9.7900306	-4.2507036 C		
0.00007375	102.0346115	1383520.	2.1412814	0.0001579	-0.0003490
0.6318697	0.00000	-10.0485928	-4.3149035 C		
0.00007625	105.6452003	1385511.	2.1783458	0.0001661	-0.0003580
0.6632941	0.00000	-10.3072644	-4.3792127 C		
0.00007875	109.2582067	1387406.	2.2129622	0.0001743	-0.0003671
0.6945425	0.00000	-10.5661524	-4.4437384 C		
0.00008125	112.8720632	1389195.	2.2454058	0.0001824	-0.0003761
0.7256306	0.00000	-10.8251405	-4.5083641 C		
0.00008375	116.4879801	1390901.	2.2758292	0.0001906	-0.0003851
0.7565451	0.00000	-11.0843309	-4.5731922 C		
0.00008625	120.1034440	1392504.	2.3044925	0.0001988	-0.0003941
0.7873142	0.00000	-11.3435125	-4.6380114 C		
0.00008875	123.7217280	1394048.	2.3314292	0.0002069	-0.0004032
0.8178992	0.00000	-11.6029816	-4.7031181 C		
0.00009125	127.3393293	1395499.	2.3569012	0.0002151	-0.0004122
0.8483417	0.00000	-11.8624209	-4.7681951 C		
0.00009375	130.9575368	1396880.	2.3809793	0.0002232	-0.0004212
0.8786255	0.00000	-12.1219562	-4.8333681 C		
0.00009625	134.5769948	1398203.	2.4037499	0.0002314	-0.0004303
0.9087427	0.00000	-12.3816502	-4.8986997 C		
0.00009875	138.1957695	1399451.	2.4253779	0.0002395	-0.0004393
0.9387178	0.00000	-12.6413142	-4.9640014 C		
0.0001013	141.8146328	1400638.	2.4459203	0.0002476	-0.0004483
0.9685402	0.00000	-12.9010299	-5.0293548 C		
0.0001038	145.4347888	1401781.	2.4654132	0.0002558	-0.0004574
0.9981940	0.00000	-13.1609244	-5.0948869 C		
0.0001063	149.0542614	1402864.	2.4839986	0.0002639	-0.0004664
1.0277058	0.00000	-13.4207889	-5.1603890 C		
0.0001088	152.6730501	1403890.	2.5017390	0.0002721	-0.0004755
1.0570756	0.00000	-13.6806234	-5.2258611 C		
0.0001113	156.2924865	1404876.	2.5186439	0.0002802	-0.0004845
1.0862842	0.00000	-13.9405812	-5.2914566 C		
0.0001138	159.9122176	1405822.	2.5347806	0.0002883	-0.0004936
1.1153368	0.00000	-14.2006217	-5.3571348 C		
0.0001163	163.5312650	1406721.	2.5502322	0.0002965	-0.0005026
1.1442476	0.00000	-14.4606322	-5.4227829 C		
0.0001188	167.1496284	1407576.	2.5650419	0.0003046	-0.0005117
1.1730165	0.00000	-14.7206125	-5.4884009 C		
0.0001213	170.7675126	1408392.	2.5792421	0.0003127	-0.0005207
1.2016402	0.00000	-14.9805887	-5.5540148 C		
0.0001238	174.3864159	1409183.	2.5928167	0.0003209	-0.0005298
1.2300957	0.00000	-15.2407507	-5.6198144 C		
0.0001263	178.0046357	1409938.	2.6058620	0.0003290	-0.0005389
1.2584094	0.00000	-15.5008826	-5.6855839 C		
0.0001288	181.6221638	1410658.	2.6184088	0.0003371	-0.0005479
1.2865809	0.00000	-15.7609880	-5.7513270 C		

```
 0.0001313   185.2390156      1411345.     2.6304855     0.0003453    -0.0005570
1.3146109      0.00000   -16.0210595    -5.8170361 C
 0.0001338   188.8551897      1412001.     2.6421185     0.0003534    -0.0005660
1.3424994      0.00000   -16.2810974    -5.8827117 C
 0.0001363   192.4716136      1412636.     2.6532984     0.0003615    -0.0005751
1.3702292      0.00000   -16.5412458    -5.9484977 C
 0.0001388   196.0879568      1413247.     2.6640621     0.0003696    -0.0005841
1.3978077      0.00000   -16.8014444    -6.0143340 C
 0.0001413   199.7036159      1413831.     2.6744521     0.0003778    -0.0005932
1.4252444      0.00000   -17.0616129    -6.0801401 C
 0.0001438   203.3185903      1414390.     2.6844879     0.0003859    -0.0006022
1.4525391      0.00000   -17.3217512    -6.1459161 C
 0.0001463   206.9328796      1414926.     2.6941878     0.0003940    -0.0006113
1.4796919      0.00000   -17.5818593    -6.2116618 C
 0.0001488   210.5464898      1415439.     2.7035686     0.0004022    -0.0006204
1.5067031      0.00000   -17.8419343    -6.2773744 C
 0.0001588   224.9972915      1417306.     2.7380913     0.0004347    -0.0006566
1.6132667      0.00000   -18.8824613    -6.5404521 C
 0.0001688   239.4386736      1418896.     2.7685710     0.0004672    -0.0006928
1.7175298      0.00000   -19.9227468    -6.8032882 C
 0.0001788   253.8705712      1420255.     2.7956812     0.0004997    -0.0007290
1.8194872      0.00000   -20.9628213    -7.0659132 C
 0.0001888   268.2933373      1421422.     2.8199455     0.0005323    -0.0007652
1.9191305      0.00000   -22.0027495    -7.3283920 C
 0.0001988   282.7050719      1422415.     2.8418525     0.0005648    -0.0008014
2.0164935      0.00000   -23.0421917    -7.5903849 C
 0.0002088   297.1068682      1423266.     2.8617022     0.0005974    -0.0008376
2.1115493      0.00000   -24.0813816    -7.8521254 C
 0.0002188   311.4988807      1423995.     2.8797715     0.0006300    -0.0008737
2.2042924      0.00000   -25.1203536    -8.1136480 C
 0.0002288   325.8797997      1424611.     2.8963345     0.0006625    -0.0009099
2.2947471      0.00000   -26.1588374    -8.3746824 C
 0.0002388   340.2495959      1425129.     2.9115808     0.0006951    -0.0009460
2.3829099      0.00000   -27.1968314    -8.6352270 C
 0.0002488   354.6087516      1425563.     2.9256517     0.0007278    -0.0009822
2.4687657      0.00000   -28.2344615    -8.8954077 C
 0.0002588   368.9578920      1425924.     2.9386624     0.0007604    -0.0010183
2.5522978      0.00000   -29.2718864    -9.1553832 C
 0.0002688   383.2958430      1426217.     2.9507679     0.0007930    -0.0010544
2.6335292      0.00000   -30.3088193    -9.4148667 C
 0.0002788   397.6225749      1426449.     2.9620659     0.0008257    -0.0010905
2.7124562      0.00000   -31.3452588    -9.6738568 C
 0.0002888   411.9380578      1426625.     2.9726405     0.0008583    -0.0011265
2.7890754      0.00000   -32.3812033    -9.9323519 C
 0.0002988   426.2422617      1426752.     2.9825645     0.0008910    -0.0011626
2.8633831      0.00000   -33.4166514   -10.1903505 C
 0.0003088   440.5353645      1426835.     2.9918942     0.0009237    -0.0011986
2.9353710      0.00000   -34.4516643   -10.4479141 C
 0.0003188   454.8180387      1426880.     3.0006631     0.0009565    -0.0012346
3.0050205      0.00000   -35.4864506   -10.7052509 C
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 0.0003288   469.0893619     1426888.    3.0089508     0.0009892    -0.0012706
3.0723491      0.00000   -36.5207381   -10.9620890 C
 0.0003388   483.3493036     1426861.    3.0168001     0.0010219    -0.0013066
3.1373532      0.00000   -37.5545253   -11.2184269 C
 0.0003488   497.5978332     1426804.    3.0242489     0.0010547    -0.0013426
3.2000291      0.00000   -38.5878107   -11.4742629 C
 0.0003588   511.8349199     1426718.    3.0313308     0.0010875    -0.0013786
3.2603732      0.00000   -39.6205927   -11.7295955 C
 0.0003688   526.0605327     1426605.    3.0380758     0.0011203    -0.0014145
3.3183816      0.00000   -40.6528699   -11.9844232 C
 0.0003788   540.2746407     1426468.    3.0445108     0.0011531    -0.0014504
3.3740507      0.00000   -41.6846405   -12.2387445 C
 0.0003888   554.4772124     1426308.    3.0506597     0.0011859    -0.0014863
3.4273768      0.00000   -42.7159032   -12.4925577 C
 0.0003988   568.6682166     1426127.    3.0565443     0.0012188    -0.0015222
3.4783561      0.00000   -43.7466562   -12.7458614 C
 0.0004088   582.8480407     1425928.    3.0621710     0.0012517    -0.0015581
3.5269769      0.00000   -44.7770545   -12.9988102 C
 0.0004188   597.0165472     1425711.    3.0675617     0.0012845    -0.0015939
3.5732386      0.00000   -45.8070540   -13.2513604 C
 0.0004288   611.1734070     1425477.    3.0727421     0.0013174    -0.0016298
3.6171435      0.00000   -46.8365415   -13.5033985 C
 0.0004388   625.3185880     1425228.    3.0777268     0.0013504    -0.0016656
3.6586876      0.00000   -47.8655154   -13.7549230 C
 0.0004488   639.4520582     1424963.    3.0825289     0.0013833    -0.0017014
3.6978672      0.00000   -48.8939740   -14.0059321 C
 0.0004588   653.5737854     1424684.    3.0871605     0.0014162    -0.0017372
3.7346784      0.00000   -49.9219156   -14.2564244 C
 0.0004688   667.6837371     1424392.    3.0916326     0.0014492    -0.0017730
3.7691173      0.00000   -50.9493388   -14.5063981 C
 0.0004788   681.7818807     1424087.    3.0959554     0.0014822    -0.0018087
3.8011800      0.00000   -51.9762417   -14.7558517 C
 0.0004888   695.8681835     1423771.    3.1001380     0.0015152    -0.0018445
3.8308627      0.00000   -53.0026229   -15.0047835 C
 0.0004988   709.9426126     1423444.    3.1041892     0.0015482    -0.0018802
3.8581615      0.00000   -54.0284806   -15.2531917 C
 0.0005088   724.0051347     1423106.    3.1081167     0.0015813    -0.0019159
3.8830723      0.00000   -55.0538131   -15.5010749 C
 0.0005188   738.0557168     1422758.    3.1119278     0.0016143    -0.0019516
3.9055913      0.00000   -56.0786189   -15.7484312 C
 0.0005288   752.0943252     1422401.    3.1156292     0.0016474    -0.0019872
3.9257145      0.00000   -57.1028961   -15.9952591 C
 0.0005388   766.1209264     1422034.    3.1192271     0.0016805    -0.0020229
3.9434378      0.00000   -58.1266432   -16.2415568 C
 0.0005488   780.1354865     1421659.    3.1227273     0.0017136    -0.0020585
3.9587573      0.00000   -59.1498584   -16.4873225 C
 0.0006088   863.9703740     1419253.    3.1418938     0.0019126    -0.0022719
3.9985095      0.00000   -65.2789079   -17.9516757 C
 0.0006688   947.3642542     1416619.    3.1586101     0.0021123    -0.0024847
3.9991935      0.00000   -71.3887769   -19.3968483 C
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    0.0007288          1030.       1413796.     3.1735226     0.0023127    -0.0026967
   3.9998017       0.00000   -77.4785961   -20.8219711 C
    0.0007888          1111.       1408523.     3.1850576     0.0025122    -0.0029097
   3.9992386       0.00000   -80.0000000   -22.2724550 CY
    0.0008488          1180.       1390683.     3.1837726     0.0027022    -0.0031321
   3.9989870       0.00000   -80.0000000   -23.9983413 CY
    0.0009088          1236.       1359998.     3.1701614     0.0028809    -0.0033659
   3.9985349       0.00000    80.0000000   -26.0535542 CY
    0.0009688          1280.       1321091.     3.1560675     0.0030574    -0.0036017
   3.9981779       0.00000    80.0000000   -28.1696702 CY
    0.0010288          1313.       1276503.     3.1466578     0.0032371    -0.0038345
   3.9991114       0.00000    80.0000000   -30.1951071 CY
    0.0010888          1339.       1229855.     3.1414903     0.0034203    -0.0040638
   4.0000000       0.00000    80.0000000   -32.1193350 CY
    0.0011488          1360.       1183714.     3.1383940     0.0036052    -0.0042913
   3.9962500       0.00000    80.0000000   -33.9925497 CY
    0.0012088          1377.       1139153.     3.1366296     0.0037914    -0.0045175
   3.9974663       0.00000    80.0000000   -35.8298734 CY
    0.0012688          1391.       1096610.     3.1360816     0.0039789    -0.0047425
   3.9978129       0.00000    80.0000000   -37.6285405 CY


Axial Thrust Force =     65.485 kips

    Bending        Bending        Bending        Depth to      Max Comp      Max Tens
  Max Conc       Max Steel     Max Casing      Max Core    Run
   Curvature        Moment        Stiffness       N Axis         Strain         Strain
   Stress         Stress         Stress         Stress    Msg
    rad/in.        in-kip         kip-in2          in            in/in          in/in
     ksi            ksi            ksi            ksi
------------- ------------- ------------- ------------- ------------- -------------
------------- ------------- ------------- ------------- ---
   0.00000125     1.9821941       1585755.   130.8447078     0.0001636     0.0001550
   0.6634288       0.00000     4.7418747     4.6446936
   0.00000250     3.9643879       1585755.    67.1411829     0.0001679     0.0001507
   0.6798868       0.00000     4.8652439     4.6708816
   0.00000375     5.9465811       1585755.    45.9068208     0.0001722     0.0001464
   0.6963063       0.00000     4.9886290     4.6970855
   0.00000500     7.9287734       1585755.    35.2897494     0.0001764     0.0001421
   0.7126872       0.00000     5.1120300     4.7233053
   0.00000625     9.9109646       1585754.    28.9195942     0.0001807     0.0001378
   0.7290294       0.00000     5.2354469     4.7495410
   0.00000750    11.8931543       1585754.    24.6728973     0.0001850     0.0001335
   0.7453331       0.00000     5.3588797     4.7757926
   0.00000875    13.8753422       1585753.    21.6396049     0.0001893     0.0001292
   0.7615981       0.00000     5.4823284     4.8020602
   0.00001000    15.8575281       1585753.    19.3646905     0.0001936     0.0001249
   0.7778244       0.00000     5.6057930     4.8283436
   0.00001125    17.8397116       1585752.    17.5953614     0.0001979     0.0001206
   0.7940121       0.00000     5.7292735     4.8546429
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0.00001250	19.8218925	1585751.	16.1799419	0.0002022	0.0001163
0.8101611	0.00000	5.8527699	4.8809581		
0.00001375	21.8040705	1585751.	15.0219113	0.0002066	0.0001120
0.8262714	0.00000	5.9762821	4.9072892		
0.00001500	23.7862452	1585750.	14.0569224	0.0002109	0.0001077
0.8423429	0.00000	6.0998103	4.9336362		
0.00001625	25.7684164	1585749.	13.2404270	0.0002152	0.0001035
0.8583757	0.00000	6.2233544	4.9599991		
0.00001750	27.7505838	1585748.	12.5406052	0.0002195	0.00009917
0.8743698	0.00000	6.3469144	4.9863780		
0.00001875	29.7327471	1585747.	11.9341222	0.0002238	0.00009488
0.8903251	0.00000	6.4704903	5.0127727		
0.00002000	31.7149060	1585745.	11.4034769	0.0002281	0.00009059
0.9062416	0.00000	6.5940821	5.0391833		
0.00002125	33.6970602	1585744.	10.9352864	0.0002324	0.00008630
0.9221194	0.00000	6.7176898	5.0656098		
0.00002250	35.6792095	1585743.	10.5191413	0.0002367	0.00008202
0.9379583	0.00000	6.8413134	5.0920522		
0.00002375	37.6613534	1585741.	10.1468241	0.0002410	0.00007773
0.9537584	0.00000	6.9649528	5.1185105		
0.00002500	39.6434918	1585740.	9.8117606	0.0002453	0.00007344
0.9695196	0.00000	7.0886082	5.1449847		
0.00002625	41.6256243	1585738.	9.5086287	0.0002496	0.00006916
0.9852420	0.00000	7.2122795	5.1714748		
0.00002750	43.6077507	1585736.	9.2330742	0.0002539	0.00006487
1.0009255	0.00000	7.3359667	5.1979809		
0.00002875	45.5898706	1585735.	8.9815001	0.0002582	0.00006059
1.0165701	0.00000	7.4596698	5.2245028		
0.00003000	47.5719837	1585733.	8.7509087	0.0002625	0.00005631
1.0321758	0.00000	7.5833888	5.2510406		
0.00003125	49.5540899	1585731.	8.5387822	0.0002668	0.00005202
1.0477426	0.00000	7.7071237	5.2775943		
0.00003250	51.5361887	1585729.	8.3429900	0.0002711	0.00004774
1.0632704	0.00000	7.8308745	5.3041639		
0.00003375	53.5182798	1585727.	8.1617172	0.0002755	0.00004346
1.0787593	0.00000	7.9546412	5.3307494		
0.00003500	55.5003631	1585725.	7.9934081	0.0002798	0.00003918
1.0942092	0.00000	8.0784238	5.3573509		
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1.1096201	0.00000	8.2022223	5.3839682		
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0.00003875	61.4465624	1585718.	7.5537176	0.0002927	0.00002634
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0.00004000	63.4286111	1585715.	7.4255019	0.0002970	0.00002206
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0.00004125	65.4106504	1585713.	7.3050702	0.0003013	0.00001778
1.1708736	0.00000	8.6975752	5.4905965		
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1.1860893	0.00000	8.8214533	5.5172933		

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0.00004375    69.3746996     1585707.     7.0848898     0.0003100    0.00000923
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0.00004500    71.3567089     1585705.     6.9839921     0.0003143    0.00000495
1.2164035      0.00000    9.0692570     5.5707347
0.00004625    73.3387078     1585702.     6.8885601     0.0003186   6.73407E-07
1.2315020      0.00000    9.1931827     5.5974792
0.00004750    75.3206957     1585699.     6.7981625     0.0003229   -0.00000360
1.2465613      0.00000    9.3171243     5.6242396
0.00004875    77.3026725     1585696.     6.7124118     0.0003272   -0.00000788
1.2615815      0.00000    9.4410818     5.6510160
0.00005125    81.2665916     1585690.     6.5534915     0.0003359   -0.00001643
1.2915043      0.00000    9.6890445     5.7046164
0.00005375    85.2304623     1585683.     6.4093953     0.0003445   -0.00002497
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1.3803312      0.00000   10.4333096     5.8657943
0.00006125    97.1211012     1585651.     6.0478900     0.0003704   -0.00005060
1.4096248      0.00000   10.6815150     5.9196375
0.00006375   101.0838367     1585629.     5.9463495     0.0003791   -0.00005914
1.4387598      0.00000   10.9297723     5.9735324
0.00006625   105.0459146     1585599.     5.8524974     0.0003877   -0.00006767
1.4677356      0.00000   11.1780774     6.0274751
0.00006875   109.0072013     1585559.     5.7654929     0.0003964   -0.00007621
1.4965516      0.00000   11.4264264     6.0814618
0.00007125   112.9675806     1585510.     5.6846135     0.0004050   -0.00008474
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0.00007625   120.8852156     1585380.     5.5388146     0.0004223    -0.0001018
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1.6102090      0.00000   12.4201961     6.2977820
0.00008125   127.6031766     1570501.     5.3967155     0.0004385    -0.0001200
1.6344321      0.00000   12.6350268     6.3182504 C
0.00008375   131.3532306     1568397.     5.3364344     0.0004469    -0.0001288
1.6616114      0.00000   12.8773892     6.3662505 C
0.00008625   135.0916540     1566280.     5.2794977     0.0004554    -0.0001375
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0.00008875   138.8197988     1564167.     5.2256382     0.0004638    -0.0001463
1.7153786      0.00000   13.3610267     6.4611632 C
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0.00009875   153.6428625     1555877.     5.0364185     0.0004973    -0.0001815
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0.0001013	157.3293540	1553870.	4.9947272	0.0005057	-0.0001903	1.8464953	0.00000	14.5648491	6.6931739	C
0.0001038	161.0078921	1551883.	4.9549461	0.0005141	-0.0001991	1.8721651	0.00000	14.8047835	6.7387460	C
0.0001063	164.6830077	1549958.	4.9170081	0.0005224	-0.0002079	1.8976716	0.00000	15.0446288	6.7842290	C
0.0001088	168.3485484	1548033.	4.8806902	0.0005308	-0.0002168	1.9229830	0.00000	15.2840825	6.8293203	C
0.0001113	172.0128364	1546183.	4.8460075	0.0005391	-0.0002256	1.9481422	0.00000	15.5235457	6.8744211	C
0.0001138	175.6676648	1544331.	4.8127262	0.0005474	-0.0002345	1.9731057	0.00000	15.7626028	6.9191158	C
0.0001163	179.3218078	1542553.	4.7808872	0.0005558	-0.0002433	1.9979202	0.00000	16.0016964	6.9638471	C
0.0001188	182.9679730	1540783.	4.7502873	0.0005641	-0.0002522	2.0225460	0.00000	16.2404405	7.0082289	C
0.0001213	186.6125318	1539072.	4.7209457	0.0005724	-0.0002611	2.0470181	0.00000	16.4791721	7.0525981	C
0.0001238	190.2520741	1537390.	4.6927326	0.0005807	-0.0002699	2.0713170	0.00000	16.7176990	7.0967627	C
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0.0001288	197.5224101	1534155.	4.6395224	0.0005973	-0.0002877	2.1194320	0.00000	17.1944882	7.1848271	C
0.0001313	201.1496037	1532568.	4.6143448	0.0006056	-0.0002966	2.1432264	0.00000	17.4325295	7.2285062	C
0.0001338	204.7760895	1531036.	4.5901173	0.0006139	-0.0003055	2.1668727	0.00000	17.6706053	7.2722196	C
0.0001363	208.4006395	1529546.	4.5667684	0.0006222	-0.0003144	2.1903634	0.00000	17.9086394	7.3158914	C
0.0001388	212.0193278	1528067.	4.5441900	0.0006305	-0.0003233	2.2136747	0.00000	18.1463887	7.3592783	C
0.0001413	215.6373030	1526636.	4.5224192	0.0006388	-0.0003322	2.2368382	0.00000	18.3841718	7.4026990	C
0.0001438	219.2542645	1525247.	4.5014090	0.0006471	-0.0003411	2.2598517	0.00000	18.6219668	7.4461317	C
0.0001463	222.8650228	1523863.	4.4810400	0.0006554	-0.0003500	2.2826832	0.00000	18.8594396	7.4892421	C
0.0001488	226.4750600	1522521.	4.4613634	0.0006636	-0.0003589	2.3053668	0.00000	19.0969432	7.5323834	C
0.0001588	240.8947815	1517447.	4.3887257	0.0006967	-0.0003945	2.3945382	0.00000	20.0463654	7.7043562	C
0.0001688	255.2832963	1512790.	4.3245121	0.0007298	-0.0004302	2.4812183	0.00000	20.9948832	7.8754246	C
0.0001788	269.6449854	1508503.	4.2673553	0.0007628	-0.0004659	2.5654349	0.00000	21.9427382	8.0458302	C
0.0001888	283.9837595	1504550.	4.2161802	0.0007958	-0.0005017	2.6472148	0.00000	22.8901843	8.2158269	C
0.0001988	298.2997285	1500879.	4.1700767	0.0008288	-0.0005374	2.7265576	0.00000	23.8371802	8.3853733	C

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 0.0002088   312.5949250     1497461.     4.1283341     0.0008618    -0.0005732
2.8034752      0.00000    24.7838306     8.5545744 C
 0.0002188   326.8752112     1494287.     4.0904403     0.0008948    -0.0006089
2.8780132      0.00000    25.7306924     8.7239868 C
 0.0002288   341.1342457     1491297.     4.0557892     0.0009278    -0.0006447
2.9501193      0.00000    26.6770868     8.8929318 C
 0.0002388   355.3814346     1488509.     4.0241122     0.0009608    -0.0006804
3.0198666      0.00000    27.6239753     9.0623708 C
 0.0002488   369.6098847     1485869.     3.9949433     0.0009937    -0.0007162
3.0871972      0.00000    28.5705839     9.2315300 C
 0.0002588   383.8258400     1483385.     3.9680856     0.0010267    -0.0007519
3.1521607      0.00000    29.5176168     9.4011136 C
 0.0002688   398.0276567     1481033.     3.9432540     0.0010597    -0.0007876
3.2147403      0.00000    30.4648636     9.5709110 C
 0.0002788   412.2138918     1478794.     3.9202083     0.0010928    -0.0008234
3.2749231      0.00000    31.4121447     9.7407426 C
 0.0002888   426.3882827     1476669.     3.8988195     0.0011258    -0.0008591
3.3327371      0.00000    32.3599334     9.9110819 C
 0.0002988   440.5496048     1474643.     3.8789017     0.0011588    -0.0008948
3.3881690      0.00000    33.3080617    10.0817609 C
 0.0003088   454.6955032     1472698.     3.8602751     0.0011919    -0.0009305
3.4411979      0.00000    34.2561979    10.2524477 C
 0.0003188   468.8294881     1470838.     3.8428725     0.0012249    -0.0009662
3.4918500      0.00000    35.2048449    10.4236452 C
 0.0003288   482.9515266     1469054.     3.8265823     0.0012580    -0.0010018
3.5401215      0.00000    36.1540041    10.5953550 C
 0.0003388   497.0606924     1467338.     3.8112912     0.0012911    -0.0010375
3.5860017      0.00000    37.1035304    10.7674320 C
 0.0003488   511.1552155     1465678.     3.7968851     0.0013242    -0.0010731
3.6294750      0.00000    38.0531372    10.9395894 C
 0.0003588   525.2377210     1464077.     3.7833316     0.0013573    -0.0011088
3.6705591      0.00000    39.0032602    11.1122630 C
 0.0003688   539.3081760     1462531.     3.7705617     0.0013904    -0.0011444
3.7092502      0.00000    39.9539010    11.2854543 C
 0.0003788   553.3665469     1461034.     3.7585134     0.0014235    -0.0011800
3.7455442      0.00000    40.9050610    11.4591650 C
 0.0003888   567.4128002     1459583.     3.7471312     0.0014567    -0.0012156
3.7794374      0.00000    41.8567420    11.6333966 C
 0.0003988   581.4445728     1458168.     3.7363255     0.0014899    -0.0012511
3.8109114      0.00000    42.8084894    11.8076946 C
 0.0004088   595.4640032     1456793.     3.7260899     0.0015230    -0.0012867
3.8399778      0.00000    43.7607253    11.9824810 C
 0.0004188   609.4712408     1455454.     3.7163863     0.0015562    -0.0013223
3.8666340      0.00000    44.7134868    12.1577931 C
 0.0004288   623.4662514     1454149.     3.7071778     0.0015895    -0.0013578
3.8908761      0.00000    45.6667756    12.3336325 C
 0.0004388   637.4490008     1452875.     3.6984307     0.0016227    -0.0013933
3.9127000      0.00000    46.6205933    12.5100009 C
 0.0004488   651.4194547     1451631.     3.6901142     0.0016559    -0.0014288
3.9321017      0.00000    47.5749417    12.6868999 C
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    0.0004588   665.3775782      1450414.     3.6822002     0.0016892    -0.0014642
   3.9490772       0.00000    48.5298224    12.8643311 C
    0.0004688   679.3226894      1449222.     3.6746516     0.0017225    -0.0014997
   3.9636202       0.00000    49.4850794    13.0421387 C
    0.0004788   693.2544212      1448051.     3.6674395     0.0017558    -0.0015351
   3.9757269       0.00000    50.4406301    13.2202401 C
    0.0004888   707.1737411      1446903.     3.6605605     0.0017891    -0.0015706
   3.9853972       0.00000    51.3967187    13.3988793 C
    0.0004988   721.0806137      1445776.     3.6539946     0.0018224    -0.0016060
   3.9926271       0.00000    52.3533469    13.5780581 C
    0.0005088   734.9750037      1444668.     3.6477236     0.0018558    -0.0016414
   3.9974123       0.00000    53.3105165    13.7577782 C
    0.0005188   748.8568753      1443580.     3.6417304     0.0018891    -0.0016767
   3.9997486       0.00000    54.2682291    13.9380415 C
    0.0005288   762.7261927      1442508.     3.6359994     0.0019225    -0.0017121
   3.9996253       0.00000    55.2264866    14.1188496 C
    0.0005388   776.5829198      1441453.     3.6305162     0.0019559    -0.0017474
   3.9994097       0.00000    56.1852907    14.3002043 C
    0.0005488   790.4270205      1440414.     3.6252673     0.0019894    -0.0017827
   3.9990591       0.00000    57.1446432    14.4821073 C
    0.0006088   873.2213808      1434450.     3.5980112     0.0021903    -0.0019943
   3.9998915       0.00000    62.9116327    15.5844005 C
    0.0006688   955.5263912      1428825.     3.5766736     0.0023919    -0.0022051
   3.9994041       0.00000    68.6985531    16.7066245 C
    0.0007288         1037.      1423503.     3.5598053     0.0025942    -0.0024152
   3.9996182       0.00000    74.5056707    17.8490456 C
    0.0007888         1119.      1418431.     3.5463570     0.0027972    -0.0026247
   3.9983844       0.00000    80.0000000    19.0109927 CY
    0.0008488         1195.      1407551.     3.5406534     0.0030051    -0.0028292
   3.9996013       0.00000    80.0000000    20.3167677 CY
    0.0009088         1254.      1380052.     3.5426332     0.0032194    -0.0030274
   3.9998886       0.00000    80.0000000    21.8051793 CY
    0.0009688         1296.      1338282.     3.5445181     0.0034338    -0.0032254
   3.9996585       0.00000    80.0000000    23.2978112 CY
    0.0010288         1328.      1290801.     3.5438544     0.0036457    -0.0034259
   3.9978437       0.00000    80.0000000    24.7209754 CY
    0.0010888         1352.      1242206.     3.5424863     0.0038569    -0.0036272
   3.9998196       0.00000    80.0000000    26.1195872 CY


Axial Thrust Force =     75.639 kips

    Bending       Bending       Bending       Depth to      Max Comp      Max Tens
  Max Conc      Max Steel    Max Casing     Max Core   Run
   Curvature      Moment       Stiffness      N Axis        Strain        Strain
   Stress        Stress        Stress        Stress    Msg
    rad/in.       in-kip       kip-in2         in           in/in         in/in
     ksi           ksi           ksi           ksi
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0.00000125	1.9777322	1582186.	150.8693890	0.0001886	0.0001800
0.7596820	0.00000	5.4677694	5.3705883		
0.00000250	3.9554641	1582186.	77.1535247	0.0001929	0.0001757
0.7759006	0.00000	5.5911387	5.3967764		
0.00000375	5.9331954	1582185.	52.5817167	0.0001972	0.0001714
0.7920806	0.00000	5.7145240	5.4229804		
0.00000500	7.9109259	1582185.	40.2959227	0.0002015	0.0001671
0.8082221	0.00000	5.8379252	5.4492005		
0.00000625	9.8886551	1582185.	32.9245344	0.0002058	0.0001628
0.8243248	0.00000	5.9613423	5.4754364		
0.00000750	11.8663829	1582184.	28.0103489	0.0002101	0.0001585
0.8403890	0.00000	6.0847754	5.5016884		
0.00000875	13.8441089	1582184.	24.5002792	0.0002144	0.0001542
0.8564145	0.00000	6.2082245	5.5279563		
0.00001000	15.8218329	1582183.	21.8677821	0.0002187	0.0001499
0.8724012	0.00000	6.3316895	5.5542401		
0.00001125	17.7995545	1582183.	19.8203332	0.0002230	0.0001456
0.8883493	0.00000	6.4551705	5.5805399		
0.00001250	19.7772734	1582182.	18.1824181	0.0002273	0.0001414
0.9042587	0.00000	6.5786675	5.6068557		
0.00001375	21.7549895	1582181.	16.8423457	0.0002316	0.0001371
0.9201294	0.00000	6.7021804	5.6331874		
0.00001500	23.7327022	1582180.	15.7256555	0.0002359	0.0001328
0.9359613	0.00000	6.8257092	5.6595351		
0.00001625	25.7104115	1582179.	14.7807976	0.0002402	0.0001285
0.9517545	0.00000	6.9492541	5.6858988		
0.00001750	27.6881169	1582178.	13.9709509	0.0002445	0.0001242
0.9675088	0.00000	7.0728148	5.7122784		
0.00001875	29.6658182	1582177.	13.2691130	0.0002488	0.0001199
0.9832244	0.00000	7.1963916	5.7386740		
0.00002000	31.6435151	1582176.	12.6550325	0.0002531	0.0001156
0.9989012	0.00000	7.3199843	5.7650855		
0.00002125	33.6212073	1582174.	12.1132226	0.0002574	0.0001113
1.0145392	0.00000	7.4435929	5.7915130		
0.00002250	35.5988944	1582173.	11.6316382	0.0002617	0.0001070
1.0301383	0.00000	7.5672176	5.8179564		
0.00002375	37.5765763	1582172.	11.2007701	0.0002660	0.0001028
1.0456986	0.00000	7.6908581	5.8444158		
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1.0612200	0.00000	7.8145147	5.8708912		
0.00002625	41.5319230	1582168.	10.4622020	0.0002746	0.00009419
1.0767025	0.00000	7.9381872	5.8973825		
0.00002750	43.5095872	1582167.	10.1433049	0.0002789	0.00008991
1.0921461	0.00000	8.0618756	5.9238898		
0.00002875	45.4872450	1582165.	9.8521571	0.0002832	0.00008562
1.1075508	0.00000	8.1855801	5.9504130		
0.00003000	47.4648960	1582163.	9.5852899	0.0002876	0.00008134
1.1229165	0.00000	8.3093004	5.9769522		
0.00003125	49.4425399	1582161.	9.3397898	0.0002919	0.00007706
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1.2744294	0.00000	9.5473820	6.2432220		
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2.0032302	0.00000	16.0530510	7.5982888 C		
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2.1969884	0.00000	17.9760510	7.9663900 C		
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2.2204254	0.00000	18.2155276	8.0115042 C		
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2.2437087	0.00000	18.4550001	8.0566144 C		
0.0001363	209.5383643	1537896.	4.7656109	0.0006493	-0.0002873
2.2668236	0.00000	18.6943159	8.1015678 C		
0.0001388	213.1730050	1536382.	4.7397882	0.0006576	-0.0002961
2.2897658	0.00000	18.9334270	8.1463166 C		

0.0001413	216.8069437	1534916.	4.7148885	0.0006660	-0.0003050
2.3125585	0.00000	19.1725743	8.1911015 C		
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2.3351721	0.00000	19.4114427	8.2356076 C		
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2.3799314	0.00000	19.8890709	8.3245110 C		
0.0001588	242.1447889	1525322.	4.5617694	0.0007242	-0.0003671
2.4675016	0.00000	20.8430155	8.5010063 C		
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2.5525295	0.00000	21.7957166	8.6762580 C		
0.0001788	270.9531353	1515822.	4.4226004	0.0007905	-0.0004382
2.6350515	0.00000	22.7474898	8.8505818 C		
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2.7150942	0.00000	23.6985709	9.0242135 C		
0.0001988	299.6402172	1507624.	4.3108945	0.0008568	-0.0005094
2.7926516	0.00000	24.6488189	9.1970121 C		
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2.9404548	0.00000	26.5483940	9.5416884 C		
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3.1439538	0.00000	29.3960217	10.0569678 C		
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3.2069731	0.00000	30.3452916	10.2287884 C		
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3.2675776	0.00000	31.2944716	10.4005190 C		
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3.3258042	0.00000	32.2441655	10.5727635 C		
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3.3816032	0.00000	33.1935753	10.7447238 C		
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3.4350171	0.00000	34.1434368	10.9171360 C		
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3.4860459	0.00000	35.0938140	11.0900638 C		
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3.5808630	0.00000	36.9946479	11.4359989 C		
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3.6660998	0.00000	38.8973677	11.7838198 C		
0.0003588	526.4843312	1467552.	3.8646153	0.0013864	-0.0010796
3.7050959	0.00000	39.8489151	11.9579179 C		

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 0.0003688   540.5400199     1465871.    3.8497747     0.0014196    -0.0011152
3.7416908      0.00000    40.8009841    12.1325375 C
 0.0003788   554.5835412     1464247.    3.8357653     0.0014528    -0.0011507
3.7758803      0.00000    41.7535763    12.3076802 C
 0.0003888   568.6148611     1462675.    3.8225232     0.0014860    -0.0011863
3.8076606      0.00000    42.7066932    12.4833477 C
 0.0003988   582.6325641     1461147.    3.8099705     0.0015192    -0.0012218
3.8370209      0.00000    43.6601013    12.6593065 C
 0.0004088   596.6360448     1459660.    3.7980482     0.0015525    -0.0012573
3.8639560      0.00000    44.6137014    12.8354572 C
 0.0004188   610.6272496     1458214.    3.7867389     0.0015857    -0.0012928
3.8884729      0.00000    45.5678305    13.0121368 C
 0.0004288   624.6061438     1456807.    3.7759998     0.0016190    -0.0013283
3.9105676      0.00000    46.5224902    13.1893471 C
 0.0004388   638.5726929     1455436.    3.7657920     0.0016522    -0.0013637
3.9302359      0.00000    47.4776822    13.3670898 C
 0.0004488   652.5268618     1454099.    3.7560803     0.0016855    -0.0013992
3.9474738      0.00000    48.4334081    13.5453663 C
 0.0004588   666.4686156     1452793.    3.7468322     0.0017189    -0.0014346
3.9622773      0.00000    49.3896697    13.7241785 C
 0.0004688   680.3957195     1451511.    3.7379849     0.0017522    -0.0014700
3.9746371      0.00000    50.3460168    13.9030762 C
 0.0004788   694.3102334     1450256.    3.7295442     0.0017855    -0.0015054
3.9845562      0.00000    51.3028764    14.0824864 C
 0.0004888   708.2122522     1449028.    3.7214871     0.0018189    -0.0015408
3.9920311      0.00000    52.2602768    14.2624374 C
 0.0004988   722.1017404     1447823.    3.7137905     0.0018523    -0.0015762
3.9970575      0.00000    53.2182197    14.4429309 C
 0.0005088   735.9786620     1446641.    3.7064334     0.0018856    -0.0016115
3.9996313      0.00000    54.1767069    14.6239687 C
 0.0005188   749.8429810     1445480.    3.6993962     0.0019191    -0.0016468
3.9995184      0.00000    55.1357400    14.8055524 C
 0.0005288   763.6946610     1444340.    3.6926610     0.0019525    -0.0016821
3.9993173      0.00000    56.0953210    14.9876840 C
 0.0005388   777.5336656     1443218.    3.6862109     0.0019859    -0.0017174
3.9989921      0.00000    57.0554514    15.1703650 C
 0.0005488   791.3599582     1442114.    3.6800306     0.0020194    -0.0017527
3.9996482      0.00000    58.0161332    15.3535974 C
 0.0006088   874.0379326     1435791.    3.6477588     0.0022206    -0.0019640
3.9994859      0.00000    63.7898645    16.4626322 C
 0.0006688   956.2253370     1429870.    3.6223578     0.0024225    -0.0021745
3.9983386      0.00000    69.5845399    17.5926113 C
 0.0007288        1038.      1424315.    3.6020497     0.0026250    -0.0023844
3.9983989      0.00000    75.3984525    18.7418274 C
 0.0007888        1119.      1418822.    3.5858366     0.0028283    -0.0025935
3.9999485      0.00000    80.0000000    19.9140407 CY
 0.0008488        1193.      1406109.    3.5796447     0.0030382    -0.0027961
3.9978155      0.00000    80.0000000    21.2764888 CY
 0.0009088        1252.      1377842.    3.5834306     0.0032564    -0.0029903
3.9985954      0.00000    80.0000000    22.8803426 CY
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0.0009688	1295.	1336883.	3.5871961	0.0034751	-0.0031841	3.9979526	0.00000	80.0000000	24.4967948 CY
0.0010288	1327.	1289584.	3.5873984	0.0036905	-0.0033811	3.9996864	0.00000	80.0000000	26.0200573 CY
0.0010888	1351.	1241209.	3.5863837	0.0039047	-0.0035794	3.9982269	0.00000	80.0000000	27.5055924 CY

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	-27.517	1265.522	0.00300000
2	65.485	1192.787	0.00300000
3	75.639	1179.897	0.00300000

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	-27.517000	1266.	-17.886050	822.589314	1420441.
2	0.65	65.485000	1193.	42.565250	775.311535	1441550.
3	0.65	75.639000	1180.	49.165350	766.933100	1444077.

1	0.75	-27.517000	1266.	-20.637750	949.141516	1416559.
2	0.75	65.485000	1193.	49.113750	894.590233	1432989.
3	0.75	75.639000	1180.	56.729250	884.922808	1435007.
1	0.90	-27.517000	1266.	-24.765300	1139.	1401323.
2	0.90	65.485000	1193.	58.936500	1074.	1421252.
3	0.90	75.639000	1180.	68.075100	1062.	1422694.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	112123.
2	10.0000	10.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 10590.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 65485.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.9690	-2.17E-07	10590.	-0.01884	0.00	1.59E+09	0.00	0.00	0.00
0.1500	0.9351	21283.	10581.	-0.01883	0.00	1.59E+09	-9.9077	19.0711	0.00
0.3000	0.9013	42531.	10553.	-0.01879	0.00	1.59E+09	-21.6192	43.1780	0.00
0.4500	0.8675	63703.	10502.	-0.01873	0.00	1.59E+09	-34.3330	71.2404	0.00
0.6000	0.8338	84755.	10429.	-0.01865	0.00	1.59E+09	-47.2477	101.9951	0.00
0.7500	0.8003	105643.	10333.	-0.01854	0.00	1.59E+09	-59.5620	133.9569	0.00
0.9000	0.7671	126324.	10216.	-0.01841	0.00	1.58E+09	-70.4745	165.3724	0.00
1.0500	0.7341	146759.	10081.	-0.01825	0.00	1.56E+09	-79.1837	194.1630	0.00
1.2000	0.7014	166918.	9933.	-0.01807	0.00	1.55E+09	-84.8883	217.8551	0.00
1.3500	0.6690	186779.	9779.	-0.01786	0.00	1.54E+09	-86.7868	233.4970	0.00
1.5000	0.6371	206333.	9625.	-0.01763	0.00	1.53E+09	-84.0779	237.5557	0.00
1.6500	0.6056	225586.	9461.	-0.01738	0.00	1.52E+09	-98.2717	292.1115	0.00
1.8000	0.5745	244490.	9270.	-0.01710	0.00	1.52E+09	-114.0916	357.4584	0.00
1.9500	0.5440	262989.	9049.	-0.01680	0.00	1.51E+09	-131.0591	433.6539	0.00
2.1000	0.5140	281027.	8797.	-0.01647	0.00	1.51E+09	-149.1743	522.3556	0.00
2.2500	0.4847	298542.	8511.	-0.01613	0.00	1.50E+09	-168.4371	625.5198	0.00
2.4000	0.4560	315468.	8190.	-0.01576	0.00	1.50E+09	-188.8476	745.4640	0.00
2.5500	0.4280	331739.	7830.	-0.01537	0.00	1.49E+09	-210.4058	884.9432	0.00
2.7000	0.4007	347280.	7431.	-0.01496	0.00	1.49E+09	-233.1112	1047.	0.00
2.8500	0.3741	362017.	6990.	-0.01453	0.00	1.49E+09	-256.9627	1236.	0.00
3.0000	0.3484	375870.	6505.	-0.01408	0.00	1.48E+09	-281.9557	1457.	0.00

3.1500	0.3234	388755.	5974.	-0.01362	0.00	1.48E+09	-308.0769	1715.	0.00
3.3000	0.2993	400586.	5395.	-0.01314	0.00	1.48E+09	-335.2909	2016.	0.00
3.4500	0.2761	411274.	4766.	-0.01264	0.00	1.48E+09	-363.5138	2370.	0.00
3.6000	0.2538	420725.	4086.	-0.01214	0.00	1.48E+09	-392.5684	2784.	0.00
3.7500	0.2324	428844.	3352.	-0.01162	0.00	1.48E+09	-422.1145	3269.	0.00
3.9000	0.2120	435533.	2566.	-0.01109	0.00	1.48E+09	-451.5599	3834.	0.00
4.0500	0.1925	440697.	1728.	-0.01056	0.00	1.47E+09	-479.9657	4488.	0.00
4.2000	0.1740	444242.	840.3413	-0.01002	0.00	1.47E+09	-505.9788	5235.	0.00
4.3500	0.1564	446084.	-90.0951	-0.00947	0.00	1.47E+09	-527.8393	6074.	0.00
4.5000	0.1399	446151.	-1054.	-0.00893	0.00	1.47E+09	-543.5075	6994.	0.00
4.6500	0.1243	444393.	-2039.	-0.00839	0.00	1.47E+09	-550.9301	7979.	0.00
4.8000	0.1097	440787.	-3029.	-0.00785	0.00	1.47E+09	-548.4084	9000.	0.00
4.9500	0.09604	435340.	-4004.	-0.00731	0.00	1.48E+09	-534.9668	10026.	0.00
5.1000	0.08336	428097.	-4945.	-0.00678	0.00	1.48E+09	-510.5936	11025.	0.00
5.2500	0.07162	419138.	-5833.	-0.00627	0.00	1.48E+09	-476.2630	11970.	0.00
5.4000	0.06079	408576.	-6652.	-0.00576	0.00	1.48E+09	-433.7353	12842.	0.00
5.5500	0.05087	396550.	-7389.	-0.00528	0.00	1.48E+09	-385.2222	13632.	0.00
5.7000	0.04180	383219.	-8035.	-0.00480	0.00	1.48E+09	-333.0326	14340.	0.00
5.8500	0.03358	368755.	-8587.	-0.00435	0.00	1.49E+09	-279.2961	14972.	0.00
6.0000	0.02616	353332.	-9041.	-0.00391	0.00	1.49E+09	-225.7997	15537.	0.00
6.1500	0.01951	337128.	-9401.	-0.00349	0.00	1.49E+09	-173.9308	16049.	0.00
6.3000	0.01359	320313.	-9670.	-0.00310	0.00	1.50E+09	-124.6951	16519.	0.00
6.4500	0.00836	303047.	-9853.	-0.00272	0.00	1.50E+09	-78.7729	16957.	0.00
6.6000	0.00379	285484.	-9957.	-0.00237	0.00	1.50E+09	-36.5876	17372.	0.00
6.7500	-1.65E-04	267762.	-9988.	-0.00204	0.00	1.51E+09	1.6289	17772.	0.00

6.9000	-0.00355	250008.	-9954.	-0.00173	0.00	1.51E+09	35.7812	18163.	0.00
7.0500	-0.00639	232334.	-9863.	-0.00144	0.00	1.52E+09	65.8694	18548.	0.00
7.2000	-0.00874	214842.	-9721.	-0.00118	0.00	1.53E+09	91.9584	18931.	0.00
7.3500	-0.01064	197618.	-9535.	-9.37E-04	0.00	1.53E+09	114.1572	19315.	0.00
7.5000	-0.01212	180736.	-9313.	-7.16E-04	0.00	1.54E+09	132.6054	19699.	0.00
7.6500	-0.01321	164259.	-9061.	-5.15E-04	0.00	1.55E+09	147.4637	20086.	0.00
7.8000	-0.01397	148237.	-8785.	-3.34E-04	0.00	1.56E+09	158.9088	20476.	0.00
7.9500	-0.01442	132710.	-8492.	-1.72E-04	0.00	1.57E+09	167.1298	20868.	0.00
8.1000	-0.01459	117706.	-8186.	-2.90E-05	0.00	1.59E+09	172.3251	21262.	0.00
8.2500	-0.01452	103245.	-7874.	9.65E-05	0.00	1.59E+09	174.7187	21659.	0.00
8.4000	-0.01424	89336.	-7560.	2.06E-04	0.00	1.59E+09	174.5109	22057.	0.00
8.5500	-0.01378	75981.	-7248.	3.00E-04	0.00	1.59E+09	171.9124	22456.	0.00
8.7000	-0.01316	63173.	-6943.	3.79E-04	0.00	1.59E+09	167.1444	22857.	0.00
8.8500	-0.01242	50897.	-6648.	4.43E-04	0.00	1.59E+09	160.4378	23258.	0.00
9.0000	-0.01157	39135.	-6367.	4.94E-04	0.00	1.59E+09	152.0331	23659.	0.00
9.1500	-0.01064	27860.	-6102.	5.32E-04	0.00	1.59E+09	142.1802	24060.	0.00
9.3000	-0.00965	17042.	-5856.	5.58E-04	0.00	1.59E+09	131.1370	24461.	0.00
9.4500	-0.00863	6647.	-5631.	5.71E-04	0.00	1.59E+09	119.1687	24860.	0.00
9.6000	-0.00759	-3363.	-5428.	5.73E-04	0.00	1.59E+09	106.5547	25260.	0.00
9.7500	-0.00656	-13028.	-5248.	5.64E-04	0.00	1.59E+09	93.5775	25659.	0.00
9.9000	-0.00556	-22387.	-5091.	5.44E-04	0.00	1.59E+09	80.5283	26057.	0.00
10.0500	-0.00461	-31483.	-4670.	5.13E-04	0.00	1.59E+09	387.3670	151353.	0.00
10.2000	-0.00372	-39320.	-3883.	4.73E-04	0.00	1.59E+09	487.0102	235957.	0.00
10.3500	-0.00290	-45573.	-2931.	4.25E-04	0.00	1.59E+09	570.6834	353755.	0.00
10.5000	-0.00219	-49971.	-1844.	3.71E-04	0.00	1.59E+09	636.5948	524296.	0.00

10.6500	-0.00157	-52300.	-656.9358	3.13E-04	0.00	1.59E+09	682.7260	783047.	0.00
10.8000	-0.00106	-52410.	593.5013	2.53E-04	0.00	1.59E+09	706.6486	1199854.	0.00
10.9500	-6.58E-04	-50223.	1864.	1.95E-04	0.00	1.59E+09	705.0942	1929131.	0.00
11.1000	-3.58E-04	-45745.	3104.	1.40E-04	0.00	1.59E+09	672.7400	3379580.	0.00
11.2500	-1.52E-04	-39081.	4247.	9.23E-05	0.00	1.59E+09	597.4931	7066899.	0.00
11.4000	-2.59E-05	-30476.	5164.	5.29E-05	0.00	1.59E+09	420.8190	2.92E+07	0.00
11.5500	3.81E-05	-20504.	5096.	2.39E-05	0.00	1.59E+09	-496.4360	2.35E+07	0.00
11.7000	6.02E-05	-12137.	4109.	5.39E-06	0.00	1.59E+09	-600.3770	1.80E+07	0.00
11.8500	5.75E-05	-5714.	3029.	-4.74E-06	0.00	1.59E+09	-599.0033	1.87E+07	0.00
12.0000	4.31E-05	-1231.	1988.	-8.68E-06	0.00	1.59E+09	-557.5284	2.33E+07	0.00
12.1500	2.63E-05	1446.	1043.	-8.56E-06	0.00	1.59E+09	-492.4378	3.38E+07	0.00
12.3000	1.23E-05	2527.	233.3006	-6.30E-06	0.00	1.59E+09	-407.5995	5.95E+07	0.00
12.4500	3.57E-06	2287.	-304.7437	-3.57E-06	0.00	1.59E+09	-190.2275	9.58E+07	0.00
12.6000	-5.17E-07	1431.	-451.1853	-1.46E-06	0.00	1.59E+09	27.5146	9.58E+07	0.00
12.7500	-1.68E-06	663.3397	-345.7971	-2.71E-07	0.00	1.59E+09	89.5834	9.58E+07	0.00
12.9000	-1.49E-06	186.0177	-193.6392	2.11E-07	0.00	1.59E+09	79.4809	9.58E+07	0.00
13.0500	-9.23E-07	-33.8113	-77.8808	2.97E-07	0.00	1.59E+09	49.1396	9.58E+07	0.00
13.2000	-4.22E-07	-94.4233	-13.4258	2.25E-07	0.00	1.59E+09	22.4770	9.58E+07	0.00
13.3500	-1.14E-07	-82.1971	12.2825	1.24E-07	0.00	1.59E+09	6.0877	9.58E+07	0.00
13.5000	2.55E-08	-50.2357	16.5387	4.92E-08	0.00	1.59E+09	-1.3586	9.58E+07	0.00
13.6500	6.27E-08	-22.6694	12.3106	7.80E-09	0.00	1.59E+09	-3.3393	9.58E+07	0.00
13.8000	5.36E-08	-5.9193	6.7371	-8.43E-09	0.00	1.59E+09	-2.8535	9.58E+07	0.00
13.9500	3.24E-08	1.5863	2.6176	-1.09E-08	0.00	1.59E+09	-1.7237	9.58E+07	0.00
14.1000	1.44E-08	3.5067	0.3764	-8.00E-09	0.00	1.59E+09	-0.7665	9.58E+07	0.00
14.2500	3.58E-09	2.9432	-0.4853	-4.34E-09	0.00	1.59E+09	-0.1909	9.58E+07	0.00

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   14.4000  -1.21E-09     1.7608    -0.5990  -1.67E-09       0.00   1.59E+09
0.06457   9.58E+07       0.00
   14.5500  -2.41E-09     0.7873    -0.4253  -2.20E-10       0.00   1.59E+09
0.1284   9.58E+07       0.00
   14.7000  -2.00E-09     0.2299    -0.2137   3.58E-10       0.00   1.59E+09
0.1066   9.58E+07       0.00
   14.8500  -1.12E-09    0.01801   -0.06383   4.99E-10       0.00   1.59E+09
0.05984   9.58E+07       0.00
   15.0000  -2.08E-10       0.00       0.00   5.09E-10       0.00   1.59E+09
0.01108   4.79E+07       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.96903931 inches
Computed slope at pile head      =    -0.01884037 radians
Maximum bending moment           =        446151. inch-lbs
Maximum shear force              =         10590. lbs
Depth of maximum bending moment  =     4.50000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             22
Number of zero deflection points =              6



--------------------------------------------------------------------------------
                 Computed Values of Pile Loading and Deflection
                   for Lateral Loading for Load Case Number 2
--------------------------------------------------------------------------------

Pile-head conditions are Shear and Rotational Stiffness (Loading Type 3)
Shear force at pile head                               =       6300.0 lb
Rotational stiffness                                   =          0.0 in-lb/rad
Axial load at pile head                                =      75639.0 lbs

   Depth    Deflect.    Bending     Shear      Slope      Total     Bending   Soil
Res.  Soil Spr.  Distrib.
     X          y       Moment      Force        S       Stress    Stiffness      p
      Es*H     Lat. Load
   feet      inches     in-lbs       lbs      radians     psi*      lb-in^2
lb/inch    lb/inch    lb/inch
---------- ---------- ---------- ---------- ---------- ---------- ----------
---------- ---------- ----------
```

```
      0.00     0.3673  -5.69E-07      6300.   -0.00801       0.00   1.58E+09
0.00      0.00      0.00
    0.1500     0.3529     12431.      6291.   -0.00800       0.00   1.58E+09
-9.9078   50.5327      0.00
    0.3000     0.3385     24827.      6263.   -0.00798       0.00   1.58E+09
-21.6194  114.9537      0.00
    0.4500     0.3242     37150.      6212.   -0.00795       0.00   1.58E+09
-34.3331  190.6322      0.00
    0.6000     0.3099     49356.      6139.   -0.00790       0.00   1.58E+09
-47.2474  274.4154      0.00
    0.7500     0.2957     61401.      6043.   -0.00784       0.00   1.58E+09
-59.5606  362.5023      0.00
    0.9000     0.2817     73244.      5926.   -0.00776       0.00   1.58E+09
-70.4716  450.2885      0.00
    1.0500     0.2678     84847.      5791.   -0.00767       0.00   1.58E+09
-79.1799  532.1735      0.00
    1.2000     0.2541     96180.      5643.   -0.00757       0.00   1.58E+09
-84.8848  601.3163      0.00
    1.3500     0.2406    107223.      5489.   -0.00745       0.00   1.58E+09
-86.7850  649.3279      0.00
    1.5000     0.2273    117969.      5335.   -0.00732       0.00   1.58E+09
-84.0779  665.8896      0.00
    1.6500     0.2142    128424.      5171.   -0.00718       0.00   1.58E+09
-98.2678  825.7188      0.00
    1.8000     0.2014    138540.      4980.   -0.00703       0.00   1.57E+09
-114.0723      1019.      0.00
    1.9500     0.1889    148266.      4759.   -0.00687       0.00   1.57E+09
-130.9906      1248.      0.00
    2.1000     0.1767    157544.      4507.   -0.00669       0.00   1.56E+09
-148.9704      1517.      0.00
    2.2500     0.1648    166314.      4222.   -0.00650       0.00   1.56E+09
-167.9033      1834.      0.00
    2.4000     0.1533    174514.      3902.   -0.00631       0.00   1.55E+09
-187.5900      2203.      0.00
    2.5500     0.1421    182079.      3547.   -0.00610       0.00   1.55E+09
-207.6998      2630.      0.00
    2.7000     0.1313    188942.      3155.   -0.00588       0.00   1.55E+09
-227.7346      3121.      0.00
    2.8500     0.1209    195038.      2727.   -0.00566       0.00   1.54E+09
-247.0121      3676.      0.00
    3.0000     0.1110    200302.      2267.   -0.00543       0.00   1.54E+09
-264.6831      4293.      0.00
    3.1500     0.1014    204677.      1777.   -0.00519       0.00   1.54E+09
-279.7934      4967.      0.00
    3.3000    0.09227    208112.      1263.   -0.00495       0.00   1.54E+09
-291.3895      5684.      0.00
    3.4500    0.08358    210571.   731.7024   -0.00471       0.00   1.54E+09
-298.6484      6432.      0.00
    3.6000    0.07533    212028.   192.0182   -0.00446       0.00   1.54E+09
-301.0008      7192.      0.00
```

3.7500	0.06753	212476.	-347.2746	-0.00421	0.00	1.54E+09	-298.2134	7949.	0.00
3.9000	0.06018	211924.	-877.0346	-0.00396	0.00	1.54E+09	-290.4089	8687.	0.00
4.0500	0.05327	210397.	-1389.	-0.00371	0.00	1.54E+09	-278.0241	9395.	0.00
4.2000	0.04681	207936.	-1874.	-0.00347	0.00	1.54E+09	-261.7240	10065.	0.00
4.3500	0.04078	204594.	-2328.	-0.00323	0.00	1.54E+09	-242.2995	10695.	0.00
4.5000	0.03519	200434.	-2745.	-0.00299	0.00	1.54E+09	-220.5730	11284.	0.00
4.6500	0.03001	195528.	-3121.	-0.00276	0.00	1.54E+09	-197.3267	11835.	0.00
4.8000	0.02525	189952.	-3454.	-0.00254	0.00	1.55E+09	-173.2577	12352.	0.00
4.9500	0.02088	183783.	-3744.	-0.00232	0.00	1.55E+09	-148.9571	12840.	0.00
5.1000	0.01690	177104.	-3991.	-0.00211	0.00	1.55E+09	-124.9071	13304.	0.00
5.2500	0.01329	169991.	-4194.	-0.00191	0.00	1.56E+09	-101.4884	13747.	0.00
5.4000	0.01003	162523.	-4357.	-0.00172	0.00	1.56E+09	-78.9936	14175.	0.00
5.5500	0.00711	154774.	-4480.	-0.00153	0.00	1.56E+09	-57.6413	14592.	0.00
5.7000	0.00451	146813.	-4566.	-0.00136	0.00	1.57E+09	-37.5906	14999.	0.00
5.8500	0.00222	138708.	-4616.	-0.00120	0.00	1.57E+09	-18.9531	15400.	0.00
6.0000	2.05E-04	130520.	-4635.	-0.00104	0.00	1.58E+09	-1.7994	15797.	0.00
6.1500	-0.00154	122305.	-4624.	-8.99E-04	0.00	1.58E+09	13.8331	16191.	0.00
6.3000	-0.00303	114117.	-4587.	-7.64E-04	0.00	1.58E+09	27.9179	16584.	0.00
6.4500	-0.00429	106001.	-4525.	-6.39E-04	0.00	1.58E+09	40.4474	16975.	0.00
6.6000	-0.00533	98000.	-4443.	-5.23E-04	0.00	1.58E+09	51.4296	17367.	0.00
6.7500	-0.00617	90150.	-4341.	-4.16E-04	0.00	1.58E+09	60.8856	17759.	0.00
6.9000	-0.00683	82484.	-4225.	-3.18E-04	0.00	1.58E+09	68.8480	18151.	0.00
7.0500	-0.00731	75028.	-4095.	-2.28E-04	0.00	1.58E+09	75.3589	18544.	0.00
7.2000	-0.00765	67805.	-3955.	-1.47E-04	0.00	1.58E+09	80.4690	18937.	0.00
7.3500	-0.00784	60831.	-3806.	-7.36E-05	0.00	1.58E+09	84.2369	19332.	0.00

7.5000	-0.00791	54122.	-3653.	-8.25E-06	0.00	1.58E+09	86.7278	19726.	0.00
7.6500	-0.00787	47684.	-3495.	4.97E-05	0.00	1.58E+09	88.0131	20122.	0.00
7.8000	-0.00773	41525.	-3337.	1.00E-04	0.00	1.58E+09	88.1693	20518.	0.00
7.9500	-0.00751	35645.	-3179.	1.44E-04	0.00	1.58E+09	87.2783	20914.	0.00
8.1000	-0.00722	30042.	-3023.	1.82E-04	0.00	1.58E+09	85.4257	21311.	0.00
8.2500	-0.00686	24711.	-2872.	2.13E-04	0.00	1.58E+09	82.7013	21707.	0.00
8.4000	-0.00645	19645.	-2726.	2.38E-04	0.00	1.58E+09	79.1981	22104.	0.00
8.5500	-0.00600	14832.	-2588.	2.58E-04	0.00	1.58E+09	75.0119	22501.	0.00
8.7000	-0.00552	10259.	-2457.	2.72E-04	0.00	1.58E+09	70.2414	22897.	0.00
8.8500	-0.00502	5913.	-2335.	2.81E-04	0.00	1.58E+09	64.9875	23294.	0.00
9.0000	-0.00451	1776.	-2223.	2.86E-04	0.00	1.58E+09	59.3537	23690.	0.00
9.1500	-0.00399	-2168.	-2122.	2.85E-04	0.00	1.58E+09	53.4452	24087.	0.00
9.3000	-0.00348	-5940.	-2031.	2.81E-04	0.00	1.58E+09	47.3697	24483.	0.00
9.4500	-0.00298	-9556.	-1951.	2.72E-04	0.00	1.58E+09	41.2370	24878.	0.00
9.6000	-0.00250	-13038.	-1882.	2.59E-04	0.00	1.58E+09	35.1593	25274.	0.00
9.7500	-0.00205	-16404.	-1824.	2.42E-04	0.00	1.58E+09	29.2515	25670.	0.00
9.9000	-0.00163	-19672.	-1777.	2.22E-04	0.00	1.58E+09	23.6309	26065.	0.00
10.0500	-0.00125	-22861.	-1504.	1.98E-04	0.00	1.58E+09	279.7585	401907.	0.00
10.2000	-9.21E-04	-25140.	-942.7833	1.70E-04	0.00	1.58E+09	343.6521	671794.	0.00
10.3500	-6.40E-04	-26301.	-281.5269	1.41E-04	0.00	1.58E+09	391.0771	1099730.	0.00
10.5000	-4.13E-04	-26192.	448.3100	1.11E-04	0.00	1.58E+09	419.8528	1828611.	0.00
10.6500	-2.40E-04	-24718.	1211.	8.22E-05	0.00	1.58E+09	427.0714	3201684.	0.00
10.8000	-1.18E-04	-21856.	1962.	5.57E-05	0.00	1.58E+09	407.9012	6246777.	0.00
10.9500	-3.97E-05	-17670.	2644.	3.32E-05	0.00	1.58E+09	349.8092	1.58E+07	0.00
11.1000	1.90E-06	-12347.	2894.	1.61E-05	0.00	1.58E+09	-71.8963	6.83E+07	0.00

11.2500	1.82E-05	-7255.	2514.	4.95E-06	0.00	1.58E+09	-350.7410	3.46E+07	0.00
11.4000	1.97E-05	-3299.	1847.	-1.05E-06	0.00	1.58E+09	-390.1597	3.56E+07	0.00
11.5500	1.44E-05	-606.1877	1144.	-3.27E-06	0.00	1.58E+09	-390.9296	4.87E+07	0.00
11.7000	7.93E-06	820.0432	466.0153	-3.15E-06	0.00	1.58E+09	-362.2905	8.22E+07	0.00
11.8500	3.10E-06	1072.	-8.4769	-2.08E-06	0.00	1.58E+09	-164.9231	9.58E+07	0.00
12.0000	4.58E-07	790.0916	-178.8658	-1.02E-06	0.00	1.58E+09	-24.3980	9.58E+07	0.00
12.1500	-5.63E-07	428.6856	-173.8498	-3.23E-07	0.00	1.58E+09	29.9713	9.58E+07	0.00
12.3000	-7.06E-07	164.3204	-113.0405	1.39E-08	0.00	1.58E+09	37.5945	9.58E+07	0.00
12.4500	-5.13E-07	21.7359	-54.6362	1.20E-07	0.00	1.58E+09	27.2992	9.58E+07	0.00
12.6000	-2.75E-07	-32.4026	-16.8965	1.14E-07	0.00	1.58E+09	14.6338	9.58E+07	0.00
12.7500	-1.03E-07	-39.1226	1.2253	7.30E-08	0.00	1.58E+09	5.5017	9.58E+07	0.00
12.9000	-1.19E-08	-28.0112	6.7489	3.48E-08	0.00	1.58E+09	0.6357	9.58E+07	0.00
13.0500	2.21E-08	-14.8359	6.2628	1.05E-08	0.00	1.58E+09	-1.1758	9.58E+07	0.00
13.2000	2.57E-08	-5.4679	3.9721	-1.09E-09	0.00	1.58E+09	-1.3695	9.58E+07	0.00
13.3500	1.82E-08	-0.5361	1.8694	-4.50E-09	0.00	1.58E+09	-0.9669	9.58E+07	0.00
13.5000	9.50E-09	1.2630	0.5438	-4.09E-09	0.00	1.58E+09	-0.5059	9.58E+07	0.00
13.6500	3.43E-09	1.4229	-0.07578	-2.56E-09	0.00	1.58E+09	-0.1826	9.58E+07	0.00
13.8000	2.72E-10	0.9909	-0.2531	-1.19E-09	0.00	1.58E+09	-0.01446	9.58E+07	0.00
13.9500	-8.57E-10	0.5120	-0.2251	-3.36E-10	0.00	1.58E+09	0.04562	9.58E+07	0.00
14.1000	-9.36E-10	0.1807	-0.1391	5.85E-11	0.00	1.58E+09	0.04987	9.58E+07	0.00
14.2500	-6.46E-10	0.01101	-0.06330	1.68E-10	0.00	1.58E+09	0.03441	9.58E+07	0.00
14.4000	-3.33E-10	-0.04719	-0.01635	1.47E-10	0.00	1.58E+09	0.01775	9.58E+07	0.00
14.5500	-1.17E-10	-0.04787	0.00525	9.29E-11	0.00	1.58E+09	0.00624	9.58E+07	0.00
14.7000	0.00	-0.02830	0.01083	4.95E-11	0.00	1.58E+09	-4.66E-05	9.58E+07	0.00
14.8500	6.11E-11	-0.00889	0.00786	2.84E-11	0.00	1.58E+09	-0.00325	9.58E+07	0.00

```
   15.0000   1.03E-10       0.00       0.00   2.33E-11       0.00   1.58E+09
-0.00549   4.79E+07       0.00
```

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection              =     0.36734221 inches
Computed slope at pile head       =    -0.00801140 radians
Maximum bending moment            =        212476. inch-lbs
Maximum shear force               =          6300. lbs
Depth of maximum bending moment   =     3.75000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =             16
Number of zero deflection points =              6
```

```
--------------------------------------------------------------------------------
                 Computed Values of Pile Loading and Deflection
                   for Lateral Loading for Load Case Number 3
--------------------------------------------------------------------------------
```

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                                =       4480.0 lbs
Applied moment at pile head                             =          0.0 in-lbs
Axial thrust load on pile head                          =     -27517.0 lbs
```

```
   Depth    Deflect.    Bending     Shear      Slope      Total     Bending   Soil
Res.  Soil Spr.  Distrib.
     X          y       Moment      Force        S       Stress    Stiffness      p
      Es*H     Lat. Load
   feet      inches     in-lbs       lbs      radians     psi*      lb-in^2
lb/inch    lb/inch    lb/inch
---------- ---------- ---------- ---------- ---------- ---------- ----------
---------- ---------- ----------
      0.00     0.1978   1.78E-07      4480.   -0.00465       0.00   1.60E+09
0.00       0.00       0.00
    0.1500     0.1894      7834.      4471.   -0.00465       0.00   1.60E+09
-9.9034    94.0988       0.00
    0.3000     0.1811     15635.      4443.   -0.00464       0.00   1.60E+09
-21.5917   214.6305       0.00
    0.4500     0.1728     23368.      4392.   -0.00461       0.00   1.34E+09
```

-34.2424	356.7936	0.00				
0.6000	0.1645	30992.	4319.	-0.00457	0.00	1.34E+09
-47.0392	514.7816	0.00				
0.7500	0.1563	38465.	4224.	-0.00453	0.00	1.34E+09
-59.1876	681.7047	0.00				
0.9000	0.1482	45748.	4108.	-0.00447	0.00	1.34E+09
-69.9220	849.3865	0.00				
1.0500	0.1402	52809.	3974.	-0.00441	0.00	1.35E+09
-78.4994	1008.	0.00				
1.2000	0.1323	59618.	3828.	-0.00433	0.00	1.35E+09
-84.1791	1145.	0.00				
1.3500	0.1246	66159.	3674.	-0.00425	0.00	1.36E+09
-86.1918	1245.	0.00				
1.5000	0.1170	72425.	3521.	-0.00416	0.00	1.36E+09
-83.7061	1287.	0.00				
1.6500	0.1096	78424.	3358.	-0.00406	0.00	1.37E+09
-97.3766	1599.	0.00				
1.8000	0.1024	84113.	3170.	-0.00395	0.00	1.37E+09
-112.0921	1970.	0.00				
1.9500	0.09542	89444.	2955.	-0.00384	0.00	1.38E+09
-127.0064	2396.	0.00				
2.1000	0.08862	94370.	2713.	-0.00372	0.00	1.38E+09
-141.6161	2876.	0.00				
2.2500	0.08204	98842.	2446.	-0.00359	0.00	1.38E+09
-155.3235	3408.	0.00				
2.4000	0.07570	102818.	2155.	-0.00346	0.00	1.38E+09
-167.4911	3983.	0.00				
2.5500	0.06960	106258.	1845.	-0.00332	0.00	1.39E+09
-177.5143	4591.	0.00				
2.7000	0.06374	109130.	1518.	-0.00318	0.00	1.39E+09
-184.8962	5221.	0.00				
2.8500	0.05814	111409.	1182.	-0.00304	0.00	1.39E+09
-189.3063	5861.	0.00				
3.0000	0.05280	113082.	839.6981	-0.00289	0.00	1.39E+09
-190.6098	6498.	0.00				
3.1500	0.04772	114145.	498.1723	-0.00275	0.00	1.39E+09
-188.8633	7124.	0.00				
3.3000	0.04291	114604.	162.3398	-0.00260	0.00	1.39E+09
-184.2839	7730.	0.00				
3.4500	0.03837	114472.	-162.9987	-0.00245	0.00	1.39E+09
-177.2034	8313.	0.00				
3.6000	0.03409	113774.	-473.6984	-0.00230	0.00	1.39E+09
-168.0186	8871.	0.00				
3.7500	0.03008	112539.	-766.3490	-0.00216	0.00	1.39E+09
-157.1487	9404.	0.00				
3.9000	0.02633	110802.	-1038.	-0.00201	0.00	1.39E+09
-145.0028	9912.	0.00				
4.0500	0.02284	108602.	-1288.	-0.00187	0.00	1.39E+09
-131.9587	10399.	0.00				
4.2000	0.01960	105982.	-1513.	-0.00173	0.00	1.39E+09

```
-118.3524     10867.        0.00
    4.3500    0.01661    102984.     -1713.   -0.00159       0.00   1.38E+09
-104.4735     11318.        0.00
    4.5000    0.01387     99656.     -1889.   -0.00146       0.00   1.38E+09
-90.5671     11756.        0.00
    4.6500    0.01135     96040.     -2040.   -0.00133       0.00   1.38E+09
-76.8367     12183.        0.00
    4.8000    0.00906     92181.     -2166.   -0.00121       0.00   1.38E+09
-63.4494     12600.        0.00
    4.9500    0.00699     88123.     -2268.   -0.00109       0.00   1.37E+09
-50.5410     13011.        0.00
    5.1000    0.00513     83906.     -2348.  -9.81E-04       0.00   1.37E+09
-38.2205     13416.        0.00
    5.2500    0.00346     79572.     -2407.  -8.73E-04       0.00   1.37E+09
-26.5746     13818.        0.00
    5.4000    0.00198     75156.     -2445.  -7.71E-04       0.00   1.36E+09
-15.6708     14216.        0.00
    5.5500   6.85E-04     70694.     -2464.  -6.75E-04       0.00   1.36E+09
-5.5606     14612.        0.00
    5.7000  -4.46E-04     66220.     -2465.  -5.84E-04       0.00   1.36E+09
3.7181     15007.        0.00
    5.8500   -0.00142     61761.     -2451.  -4.99E-04       0.00   1.35E+09
12.1397     15402.        0.00
    6.0000   -0.00224     57346.     -2422.  -4.20E-04       0.00   1.35E+09
19.6889     15795.        0.00
    6.1500   -0.00293     52998.     -2381.  -3.46E-04       0.00   1.35E+09
26.3599     16189.        0.00
    6.3000   -0.00349     48740.     -2328.  -2.78E-04       0.00   1.34E+09
32.1555     16583.        0.00
    6.4500   -0.00393     44589.     -2266.  -2.16E-04       0.00   1.34E+09
37.0865     16977.        0.00
    6.6000   -0.00427     40561.     -2196.  -1.58E-04       0.00   1.34E+09
41.1711     17371.        0.00
    6.7500   -0.00450     36669.     -2119.  -1.06E-04       0.00   1.34E+09
44.4343     17765.        0.00
    6.9000   -0.00465     32923.     -2036.  -5.97E-05       0.00   1.34E+09
46.9069     18159.        0.00
    7.0500   -0.00472     29332.     -1950.  -1.79E-05       0.00   1.34E+09
48.6237     18554.        0.00
    7.2000   -0.00471     25900.     -1862.   1.93E-05       0.00   1.34E+09
49.6239     18949.        0.00
    7.3500   -0.00465     22631.     -1772.   5.18E-05       0.00   1.35E+09
49.9499     19345.        0.00
    7.5000   -0.00453     19525.     -1683.   7.79E-05       0.00   1.60E+09
49.6502     19740.        0.00
    7.6500   -0.00437     16581.     -1594.   9.82E-05       0.00   1.60E+09
48.8553     20136.        0.00
    7.8000   -0.00417     13796.     -1507.   1.15E-04       0.00   1.60E+09
47.6070     20531.        0.00
    7.9500   -0.00395     11166.     -1423.   1.29E-04       0.00   1.60E+09
```

```
45.9487     20927.       0.00
    8.1000   -0.00371     8686.     -1342.   1.41E-04       0.00   1.60E+09
43.9250     21322.       0.00
    8.2500   -0.00345     6348.     -1265.   1.49E-04       0.00   1.60E+09
41.5816     21718.       0.00
    8.4000   -0.00317     4145.     -1193.   1.55E-04       0.00   1.60E+09
38.9651     22113.       0.00
    8.5500   -0.00289     2070.     -1125.   1.58E-04       0.00   1.60E+09
36.1227     22509.       0.00
    8.7000   -0.00260   110.6745     -1063.   1.60E-04       0.00   1.60E+09
33.1026     22904.       0.00
    8.8500   -0.00231    -1741.     -1006.   1.59E-04       0.00   1.60E+09
29.9533     23300.       0.00
    9.0000   -0.00203    -3496.  -955.0797   1.56E-04       0.00   1.60E+09
26.7241     23695.       0.00
    9.1500   -0.00175    -5164.  -909.9095   1.51E-04       0.00   1.60E+09
23.4650     24090.       0.00
    9.3000   -0.00149    -6756.  -870.5872   1.44E-04       0.00   1.60E+09
20.2265     24485.       0.00
    9.4500   -0.00123    -8284.  -837.0291   1.36E-04       0.00   1.60E+09
17.0603     24880.       0.00
    9.6000   -9.98E-04    -9756.  -809.0579   1.26E-04       0.00   1.60E+09
14.0188     25275.       0.00
    9.7500   -7.82E-04   -11184.  -786.4009   1.14E-04       0.00   1.60E+09
11.1557     25671.       0.00
    9.9000   -5.89E-04   -12576.  -768.6875   1.00E-04       0.00   1.60E+09
8.5259     26066.       0.00
   10.0500   -4.21E-04   -13941.  -569.3305   8.55E-05       0.00   1.60E+09
212.9819    911070.       0.00
   10.2000   -2.81E-04   -14617.  -147.7368   6.94E-05       0.00   1.60E+09
255.4555   1636037.       0.00
   10.3500   -1.71E-04   -14466.   335.2267   5.30E-05       0.00   1.60E+09
281.1705   2960647.       0.00
   10.5000   -9.01E-05   -13405.   846.5711   3.73E-05       0.00   1.60E+09
286.9900   5730596.       0.00
   10.6500   -3.65E-05   -11415.      1345.   2.34E-05       0.00   1.60E+09
266.8179   1.32E+07       0.00
   10.8000   -6.00E-06    -8561.      1750.   1.21E-05       0.00   1.60E+09
182.8311   5.49E+07       0.00
   10.9500   7.16E-06    -5115.      1710.   4.43E-06       0.00   1.60E+09
-227.2199   5.71E+07       0.00
   11.1000   9.96E-06    -2405.      1258.   2.01E-07       0.00   1.60E+09
-274.2754   4.96E+07       0.00
   11.2500   7.89E-06  -584.4425   755.4785  -1.48E-06       0.00   1.60E+09
-284.5113   6.49E+07       0.00
   11.4000   4.63E-06   314.4209   310.4996  -1.63E-06       0.00   1.60E+09
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   11.7000   4.64E-07   433.0511   -77.6667  -6.13E-07       0.00   1.60E+09
```

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-24.5059   9.50E+07       0.00
   11.8500  -2.00E-07   253.5332   -90.1320  -2.26E-07       0.00   1.60E+09
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18.6737   9.58E+07       0.00
   12.1500  -2.81E-07    24.0821   -33.4484   5.21E-08       0.00   1.60E+09
14.9790   9.58E+07       0.00
   12.3000  -1.63E-07   -11.8558   -12.1501   5.90E-08       0.00   1.60E+09
8.6858   9.58E+07       0.00
   12.4500  -6.90E-08   -19.6524    -1.0281   4.12E-08       0.00   1.60E+09
3.6719   9.58E+07       0.00
   12.6000  -1.46E-08   -15.5530     2.9772   2.14E-08       0.00   1.60E+09
0.7785   9.58E+07       0.00
   12.7500   8.20E-09    -8.9322     3.2848   7.65E-09       0.00   1.60E+09
-0.4368   9.58E+07       0.00
   12.9000   1.29E-08    -3.7270     2.2723   5.26E-10       0.00   1.60E+09
-0.6883   9.58E+07       0.00
   13.0500   1.01E-08    -0.7520     1.1690  -2.00E-09       0.00   1.60E+09
-0.5376   9.58E+07       0.00
   13.2000   5.74E-09     0.4811     0.4099  -2.15E-09       0.00   1.60E+09
-0.3058   9.58E+07       0.00
   13.3500   2.36E-09     0.7234    0.02136  -1.47E-09       0.00   1.60E+09
-0.1259   9.58E+07       0.00
   13.5000   4.52E-10     0.5578    -0.1136  -7.48E-10       0.00   1.60E+09
-0.02408   9.58E+07       0.00
   13.6500  -3.30E-10     0.3143    -0.1195  -2.58E-10       0.00   1.60E+09
0.01757   9.58E+07       0.00
   13.8000  -4.75E-10     0.1276   -0.08090  -8.89E-12       0.00   1.60E+09
0.02531   9.58E+07       0.00
   13.9500  -3.62E-10    0.02301   -0.04078   7.59E-11       0.00   1.60E+09
0.01927   9.58E+07       0.00
   14.1000  -2.02E-10   -0.01917   -0.01375   7.81E-11       0.00   1.60E+09
0.01076   9.58E+07       0.00
   14.2500  -8.09E-11   -0.02650  -1.94E-04   5.23E-11       0.00   1.60E+09
0.00431   9.58E+07       0.00
   14.4000  -1.36E-11   -0.01987    0.00433   2.62E-11       0.00   1.60E+09
7.22E-04   9.58E+07       0.00
   14.5500   1.36E-11   -0.01090    0.00433   8.93E-12       0.00   1.60E+09
-7.22E-04   9.58E+07       0.00
   14.7000   1.86E-11   -0.00426    0.00279       0.00       0.00   1.60E+09
-9.90E-04   9.58E+07       0.00
   14.8500   1.50E-11  -8.37E-04    0.00118  -2.47E-12       0.00   1.60E+09
-7.99E-04   9.58E+07       0.00
   15.0000   9.71E-12       0.00       0.00  -2.94E-12       0.00   1.60E+09
-5.17E-04   4.79E+07       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
```

polated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

```
Pile-head deflection              =     0.19781589 inches
Computed slope at pile head       =    -0.00465346 radians
Maximum bending moment            =        114604. inch-lbs
Maximum shear force               =          4480. lbs
Depth of maximum bending moment   =     3.30000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =             13
Number of zero deflection points  =              6
```

Summary of Pile-head Responses for Conventional Analyses

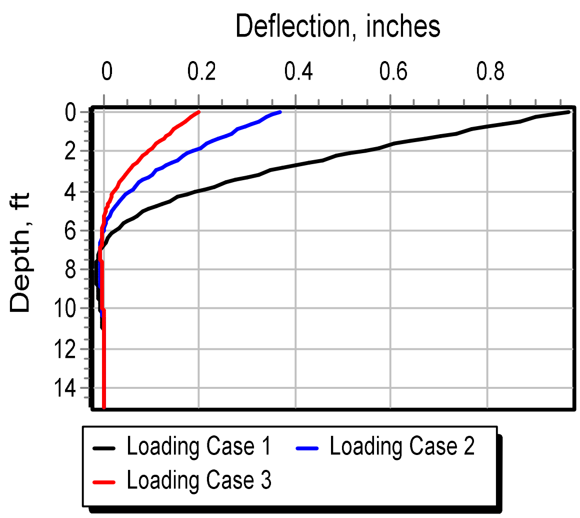
Definitions of Pile-head Loading Conditions:

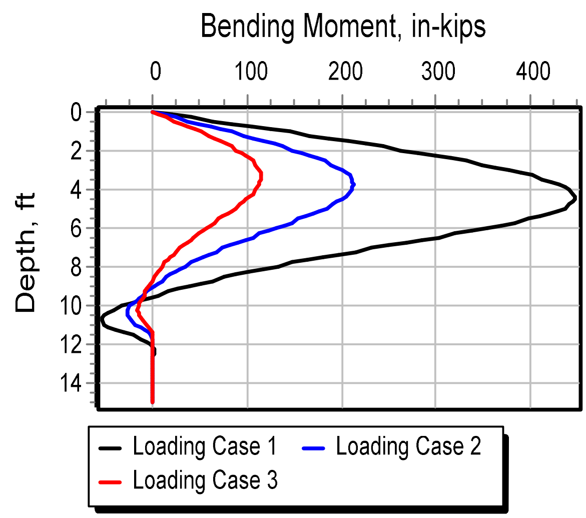
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

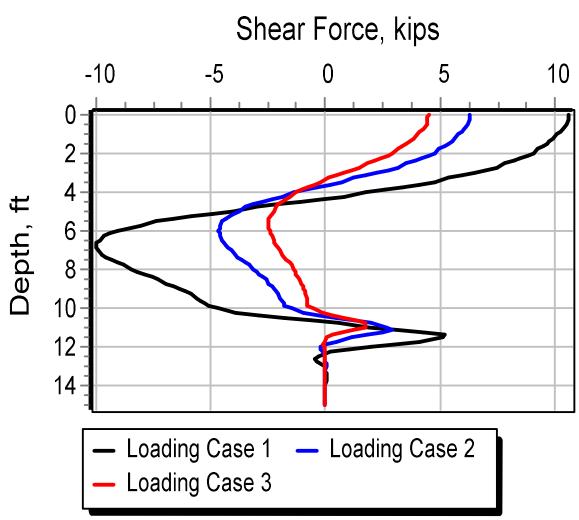
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	10590.	M, in-lb	0.00	65485.	0.9690	-0.01884	10590.	446151.
2	V, lb	6300.	R, in-lb/r	0.00	75639.	0.3673	-0.00801	6300.	212476.
3	V, lb	4480.	M, in-lb	0.00	-27517.	0.1978	-0.00465	4480.	114604.

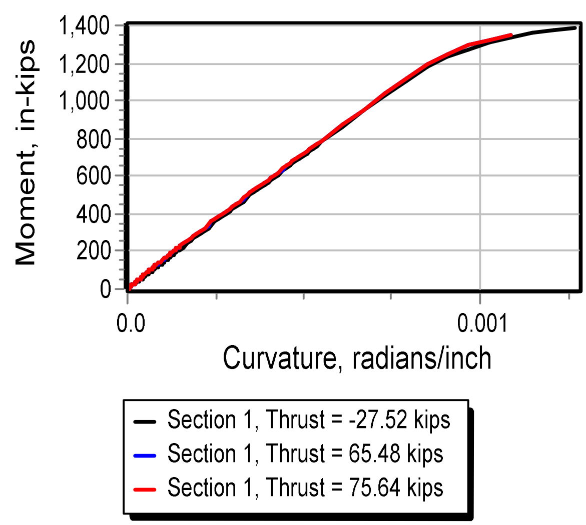
Maximum pile-head deflection = 0.9690393060 inches
Maximum pile-head rotation   = -0.0188403738 radians = -1.079474 deg.

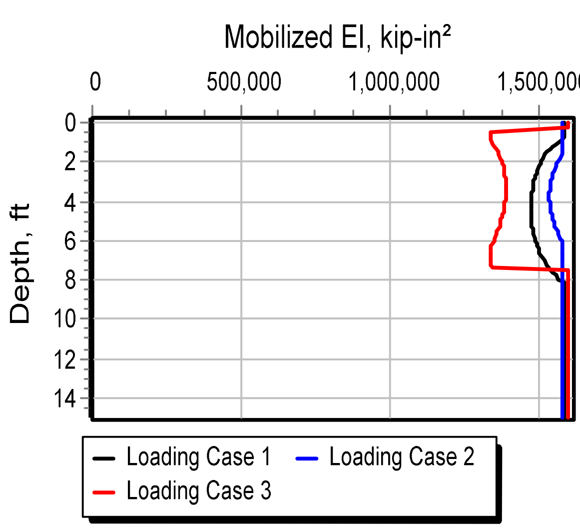
The analysis ended normally.

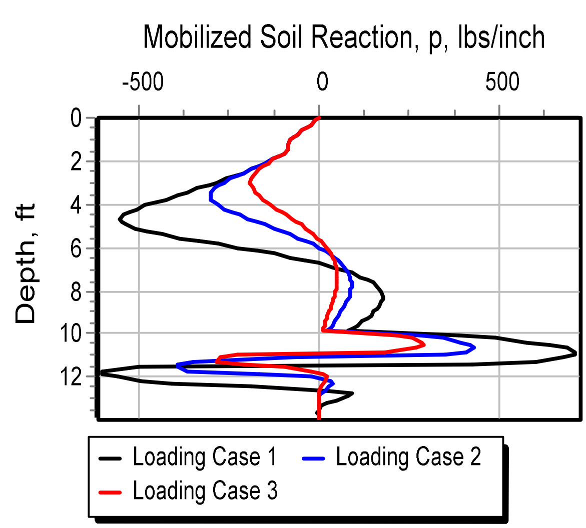

Deflection, inches
0
0.2
0.4
0.6
0.8
Depth, ft
0
2
4
6
8
10
12
14
Loading Case 1
Loading Case 2
Loading Case 3


Bending Moment, in-kips
0
100
200
300
400
Depth, ft
0
2
4
6
8
10
12
14
Loading Case 1
Loading Case 2
Loading Case 3


Shear Force, kips
-10
-5
0
5
10
Depth, ft
0
2
4
6
8
10
12
14
Loading Case 1
Loading Case 2
Loading Case 3


Moment, in-kips
1,400
1,200
1,000
800
600
400
200
0
0.0
0.001
Curvature, radians/inch
Section 1, Thrust = -27.52 kips
Section 1, Thrust = 65.48 kips
Section 1, Thrust = 75.64 kips


Mobilized EI, kip-in²
0
500,000
1,000,000
1,500,000
Depth, ft
0
2
4
6
8
10
12
14
Loading Case 1
Loading Case 2
Loading Case 3


Mobilized Soil Reaction, p, lbs/inch
-500
0
500
Depth, ft
0
2
4
6
8
10
12
Loading Case 1
Loading Case 2
Loading Case 3

verdantas

CALCULATIONS

Date:	12/9/2024	**Prepared by:**	CJS	12/9/2024
Project No.:	16667	**Checked by:**	CJVH	12/10/2024
Subject:	Micropile Calculation - Fish Ladder	**Reviewed by:**	MCP	12/10/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

The purpose of this analysis is to perform structural checks for the selected micropile design section based on the lateral response from the LPile analysis. This is an iterative design process and only the final iteration is presented herein. This design check generally follows the procedure outlined in Reference 1.

Calculated Cells   Input Parameters

References:

1. Sabatini et. al. (2005). "Micropile Design and Construction (Reference Manual for NHI Course 132078)," National Highway Institute, Washington D.C.

Assumptions:

1. Micropiles are adequately spaced such that there are not group effects (i.e., at least 30 inches or 3 micropile diameters, whichever is greater).

2. Assume initial casing has a 7 inch outside diameter, 0.5 inch casing wall thickness, and steel with 80ksi yield stress. There is little known about the Site's corrosion potential, so it is assumed that the Site will have aggressive ground conditions. Therefore, 0.063 inches of steel loss is conservatively assumed (per Reference 1) on the outside of the casing during the design life, reducing the outside casing diameter to 6.87 inches and wall thickness to 0.44 inch.

3. From structural analysis:
Maximum compressive load = 76 kips
Maximum tensile load = 27.5 kips
Maximum lateral load = 10.6 kips
Maximum bending moment from LPILE analysis = 446.2 in-kips

Calculation:

1. Select micropile diameter and material properties

	Steel Casing		
Casing Outside Diameter, OD =	6.874	in	(with corrosion reduction as stated in Assumption 2)
Wall Thickness =	0.437	in	(with corrosion reduction as stated in Assumption 2)
Casing Inside Diameter, ID =	6	in	
Area of Steel Casing, A_{casing} =	8.8	in^2	
Nomial Yield Stress $F_{y\text{-}casing}$=	80	ksi	(assumed, typical for micropile design and construction)

	Reinforcing Bar		
Steel Bar Size =	#10		(#10 threadbar, selected based on preliminary analyses)
Steel Bar Diameter =	1.43	in	(#10 threadbar, selected based on preliminary analyses)
Area of Steel Bar, A_{bar} =	1.27	in^2	(#10 threadbar, selected based on preliminary analyses)
Nomial Yield Stress $F_{y\text{-}bar}$=	75	ksi	(assumed, typical for micropile design and construction)

	Grout Strength		
28-day Unconfined Compressive Strength (f'_c) =	4	ksi	(assumed, typical for micropile design and construction)
Drill Hole Diameter, Db=	7	in	(assumed, based on uncorroded casing diameter)
Area of Grout, A_{grout} =	28.4	in^2	(drill hole area minus steel casing and threadbar areas)

2. Check strain compatibility of Grout, Casing and Reinforcing Bar

According to Section 8.16.2.3 of AASHTO (2002), "the maximum usable strain at the extreme concrete compression fiber is equal to 0.003". Therefore, if the grout is limited to a compression strain of 0.003, the steel components must also be limited to this value. The stress in the steel at this strain level is equal to the Young's modulus of steel, E, multiplied by strain (i.e., 0.003). For a typical E for steel of 200,000 MPa (29,000 ksi), the allowable steel yield stress is then 200,000 MPa × 0.003 = 600 MPa (87 ksi). Therefore, the maximum stress based on considerations of grout failure is 600 MPa (87 ksi).

Nomial Yield Stress $F_{y\text{-grout crushing}}$=	87	ksi

Use minimum yield strength of casing, bar, and grout crushing for structural design check as the minimum yield stress will control the evaluation:

Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ =	75	ksi

3. Evaluate Allowable Compression Load for Cased Length

The following equation factors the strength contributions of the grout, casing and central bar to calculate the allowable compression load for the cased length of the micropile. This does not consider and axial reduction due to structual bending of the micropile.

$$P_{c-allowable} = \left[0.4\, f'_{c-grout} \times A_{grout} + 0.47\, F_{y-steel}\left(A_{bar} + A_{casing}\right)\right]$$ (Eq. 5-1, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	As defined in Step 1 of this calculation
Area of Grout, A_{grout} =	28.4	in^2	As defined in Step 1 of this calculation
Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.43	in^2	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	8.8	in^2	As defined in Step 1 of this calculation
$P_{c\text{-allowable}}$ =	402	kips	Calculated from Eq. 5-1, above.
Max. Applied Compression Load (P_c) =	76	kips	From Structural Engineer's analysis. This is the maximum compression load.

The allowable compression load is significantly larger than the applied compression load; therefore, axial failure of the cased micropile section in compression is not expected.

4. Evaluate Allowable Tension Load for Cased Length

The following equation factors the strength contributions casing and central bar to calculate the allowable tension load for the cased length of the micropile. This does not consider and axial reduction due to structual bending of the micropile. Additionally, the contribution of the grout is ignored as it performs poorly in tension and should not be relied upon for design.

$$P_{t-allowable} = 0.55\, F_{y-steel} \times \left(A_{bar} + A_{casing}\right)$$ (Eq. 5-2, Reference 1)

Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ =	76	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.43	in^2	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	8.8	in^2	As defined in Step 1 of this calculation
$P_{t\text{-allowable}}$ =	417	kips	Calculated from Eq. 5-2, above.
Max. Applied Tensile Load (P_t) =	27.5	kips	From Structural Engineer's analysis. This is the maximum tensile load .

The allowable tensile load is significantly larger than the applied tensile load; therefore, axial failure of the cased micropile section in tension is not expected.

5. Combined Axial Compression and Bending of Cased Length

The following equation (Eq. 5-3) is used to check that the compression and lateral loads applied to the piles do not exceed the structural capacity of the micropile section. This check is performed to confirm the results of the LPile analysis, described in a separate calculation package. This assumes that all of the bending stress is carried by the casing within the cased length of the micropile and ignores the contributions of the central threadbar and grout. The calculated stress ratio in Eq. 5-3 should be maintained below 1.0.

$$\frac{f_a}{F_a}+\frac{f_b}{\left(1-\frac{f_a}{F_e^{'}}\right)F_b}\leq 1.0$$ (Eq. 5-3, Reference 1)

The following equations are used to support the structual capacity check in Eq. 5-3, above:

Area of casing:	$A_{casing}=\frac{\pi}{4}(OD^2-ID^2)$	(Eq. 5-4a, Reference 1)
Section modulus of casing:	$S=\frac{I_{casing}}{(OD/2)}$	(Eq. 5-4b, Reference 1)
Moment of inertia of casing:	$I_{casing}=\frac{\pi}{64}\left(OD^4-ID^4\right)$	(Eq. 5-4c, Reference 1)
Euler's buckling stress:	$F_e^{'}=\frac{\pi^2 E}{FS\,(Kl/r)^2}$	(Eq. 5-5, Reference 1)

Applied Compresion Load (P_c) =	65.5	kips	From Structural Engineer's analysis. This is the axial load associated with the largest lateral force in Case 1 from the LPile analysis.
Applied Maximum Moment (M_{max}) =	447	kip-in	Maximum bending moment from LPILE analysis for Case 1.
A_{casing} =	8.8	in^2	Calculated using Eq. 5-4a. Assumed for the corroded casing section described previously.
Casing Outside Diameter, OD =	6.874	in	Calculated in Step 1 of this calculation.
Casing Inside Diameter, ID =	6	in	Calculated in Step 1 of this calculation.
Moment of Inertia, I_{casing} =	46.0	in^4	Calculated from Eq. 5-4c.
Section Modulus, S =	13.4	in^3	Calculated from Eq. 5-4b.
Applied Axial Stress, f_a = (P_c/A_{casing})=	7.41	ksi	Calculates the applied axial stress in pile assuming the axial load is fully carried by the casing cross section. This is subsequently used in Eq. 5-3.
Applied Bending Stress, f_b = (M_{max}/S)=	33.41	ksi	Calculates the applied bending stress in pile assuming the bending moment is fully carried by the casing cross section. This is subsequently used in Eq. 5-3.
Allowable Axial Stress, F_a = (0.47 x $F_{y\text{-}casing}$) =	37.6	ksi	This uses the yield stress of the casing assign in Step 1 of this calculation. This is subsequently used in Eq. 5-3.
Allowable Bending Stress, F_b = (0.55 x $F_{y\text{-}casing}$) =	44.0	ksi	This uses the yield stress of the casing assign in Step 1 of this calculation. This is subsequently used in Eq. 5-3.
Elastic Modulus of Steel (E) =	29000	ksi	Assumed for use in Eq. 5-5.
Effective Length Factor, K =	1		Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.
Factor of Safety, FS =	2.12		Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.

Unsupported Length of Micropile, l =	36 in	This is an assumed length over which the micropile could be passing through very weak soils or voids. Based on the boring logs, it is expected that there could be rock or rubble fill on the site but there weren't any large voids encountered. As such, the unsupported length is assumed to be minimal and is conservatively assumed to be 36 inches.
Radius of Gyration of Casing (r), SQRT(I_{casing}/A_{casing}) =	2.3 in	Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.
Euler Bucking Stress, F'_e =	542 ksi	Calculated using Eq. 5-5 and subsequently used in Eq. 5-3.
Per Eq. 5-3, Ref 1 =	0.967	VALUE IS LESS THAN 1. THE CHECK PASSES.

As a double check of the combined stress check, the Richards and Rothbauer (Eq. 5-6, below) approach is used. This approach assumes the risk of pile buckling is negligible, but does account for the contribution of the central bar and grout to capacity. As such, if the pile is properly restrained against buckling, it is expected that this check will indicate slighly lower combined stress ratio than the above check.

$$\frac{P_c}{P_{c-allowable}} + \frac{M_{max}}{M_{allowable}} \leq 1.0$$ (Eq. 5-6, Reference 1)

Applied Axial Load (P_c) =	65.5 kips	From Structural Engineer's analysis. This is the axial load associated with the largest lateral force in Case 1 from the LPile analysis.
$P_{c\text{-allowable}}$ =	402 kips	Previously calculated from Eq. 5-1, above.
Applied Maximum Moment (M_{max}) =	447 kip-in	Maximum bending moment from LPILE analysis for Case 1.
Allowable Moment (Fb x S), M_{allow} =	589 kip-in	
Per Eq. 5-6, Ref 1 =	0.922	VALUE IS LESS THAN 1. THE CHECK PASSES.

6. Evaluate Allowable Compression Load for Uncased Length

The compression load will be transferred through the cased section and into the uncased section. As such, the allowable compression load for the uncased length must be checked to verify that it is not exceeded.

$$P_{c-allowable} = \left(0.4 f'_c \times A_{grout} + 0.47 F_{y-bar} \times A_{bar}\right)$$ (Eq. 5-7, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4 ksi	As defined in Step 1 of this calculation
Area of Grout, A_{grout} =	28.4 in^2	As defined in Step 1 of this calculation
Nominal Yield Stress of Bar, $F_{y\text{-bar}}$ =	75 ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.27 in^2	As defined in Step 1 of this calculation
$P_{c\text{-allowable}}$ =	90 kips	
Max. Applied Compression Load (P_c) =	76 kips	From Structural Engineer's analysis. This is the maximum compression load.

The allowable compression load is larger than the applied compression load; therefore, axial failure of the cased micropile section in compression is not expected.

7. Evaluate Allowable Tensile Load for Uncased Length

$$P_{t-allowable} = 0.55 F_{y-bar} \times A_{bar}$$

(Eq. 5-8, Reference 1)

Nominal Yield Stress of Bar, $F_{y\text{-}bar}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.27	in^2	As defined in Step 1 of this calculation
$P_{t\text{-}allowable}$ =	52	kips	
Max. Applied Tensile Load (P_t) =	27.5	kips	From Structural Engineer's analysis. This is the maximum tensile load .

The allowable tensile load is larger than the applied tensile load; therefore, axial failure of the cased micropile section in tension is not expected.

8. Calculate Required Uncased Bond Length

This step calculates the required bond length needed to carry the maximum compression and tensile loads. This calculation assumes that the entire load is carried by the uncased length of the pile.

$$L_b = \frac{P_{G-allowable} \times FS}{\alpha_{bond} \times \pi \times D_b}$$

(Eq. 5-10, Reference 1)

Grout to Ground Ultimate Bond Strength, α_{bond} =	100	psi, (Table 5-3, Reference 1) Assume typical strength of generally weaker rock given the poor quality of rock core collected	
Factor of Safety, FS =	2.5	2.0 is typically used, but increased to account for poor quality rock	
Drill Hole Diameter, D_b=	7	in	Assumed, based on size of the uncorroded casing.
Applied Maximum Tension Load, Pt =	27.5	kips	From Structural Engineer's analysis. This is the maximum tensile load .
Applied Maximum Compressive Load, Pc =	76	kips	From Structural Engineer's analysis. This is the maximum compression load .

Calculate bond length in compression and tension by substituting Applied Pc and Pt into Eq. 5-10 for $P_{G\text{-}allowable}$.

Lb, tension =	2.6	ft	This is the required bond length required to carry the maximum tensile load.
Lb, compression =	7.2	ft	This is the required bond length required to carry the maximum compression load.

9. Determine ultimate loads for field testing program.

This step calculates the ultimate compression and tensile capacity of the micropile. These are used in developing the field testing program. As such, the initial pre-corrosion casing dimensions are used in this evaluation.

$$P_{ult-compression} = \left[0.85 f'_{c-grout} \times A_{grout} + f_{y-casing} \times A_{casing} + f_{y-bar} \times A_{bar}\right]$$

(Eq. 5-23, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	As defined in Step 1 of this calculation
Drill Hole Diameter, Db=	7	in	Assumed, based on size of the uncorroded casing.
Casing Outside Diameter, OD =	7	in	Based on size of the uncorroded casing.
Area of Grout, A_{grout} =	27.0	in^2	Drill hole area minus steel casing area (7" OD, Casing)
Nomial Yield Stress $F_{y\text{-}casing}$=	80	ksi	As defined in Step 1 of this calculation
Wall Thickness =	0.5	in	Based on size of the uncorroded casing.
Casing Inside Diameter, ID =	6	in	Based on size of the uncorroded casing.
Area of Steel Casing, A_{casing} =	10.2	in^2	Based on size of the uncorroded casing.
Steel Bar Size =	#10		As defined in Step 1 of this calculation

Steel Bar Diameter =	1.43	in	As defined in Step 1 of this calculation
Area of Steel Bar, A_{bar} =	1.27	in^2	As defined in Step 1 of this calculation
Nomial Yield Stress F_{y-bar}=	75	ksi	As defined in Step 1 of this calculation

$P_{ult-compression}$ = 1004 kips

$$P_{ult-tension} = \left[f_{y-casing} \times A_{casing} + f_{y-bar} \times A_{bar} \right]$$ (Eq. 5-24, Reference 1)

Nomial Yield Stress $F_{y-casing}$=	80	ksi	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	10.2	in^2	Based on size of the uncorroded casing.
Area of Steel Bar, A_{bar} =	1.27	in^2	As defined in Step 1 of this calculation
Nomial Yield Stress F_{y-bar}=	75	ksi	As defined in Step 1 of this calculation
$P_{ult-tension}$ =	912	kips	

Conclusion:

The following micropile section is recommended to carry the proposed loading conditions (allowing for corrosion):

Casing API N-80 Pipe

Casing Requirements

Casing Outside Diameter, OD = **7 in**

Wall Thickness = **0.5 in**

Nomial Yield Stress $F_{y-casing}$= **80 ksi**

Casing Length = **15 ft**

Threaded casing connections will not be permitted.

Grout/Concrete Requirements

Grout/concrete 28-day Unconfined Compressive Strength (f'_c) = **4 ksi**

Reinforcing Core Requirements

Steel Bar Size = **#10 DSI Threadbar, Epoxy Coated**

Uncased Length

Minimum Uncased Length = **8 ft**

Testing Requirements

A minimum of one verification test will be required for the project to demonstrate the micropiles can carry a minimum of 2.5 times the design tension (Design Load = 27.5kips) and compression loads (Design Load = 76kips).

Proof testing on a minimum 5 percent of installed piles (with a minimum of one proof test per substructure unit) are required to demonstrate the micropiles can be loaded to 1.6 times the design tension (Design Load = 27.5kips) and compression loads (Design Load = 76kips).

Pile testing loads may not exceed 80% of the ultimate compression (1004 kips) and tension (912 kips) capacities calculated herein.

verdantas

CALCULATIONS

Date:	10/17/2024	**Prepared by:**	CJVH	10/17/2024
Project No.:	16667	**Reviewed by:**	MCP	11/26/2024
Subject:	Micropile Calculation - Exit Flume: Column Support	**Checked by:**	CJS	12/2/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

Verdantas performed calculations to assess micropile response to combined compression and lateral loading at the proposed exit flume column support foundation location using the LPile software package. The evalution was performed to identify critical micropile loading conditions (i.e., generating the maximum bending moment on the pile below the ground surface), depth to negligible lateral forces on the pile (to determine bottom of casing length), and estimated pile head deflection. This narrative accompanying our calculations documents assumptions and input parameters used in this analysis.

References:

1. Sabatini et. al. (2005). "Micropile Design and Construction (Reference Manual for NHI Course 132078)," National Highway Institute, Washington D.C.

2. Software Package: LPile 2019.11.09 by Ensoft, Inc.

3. FB-MultiPier Soil Parameter Table (US Customary Units). Bridge Software Institute.

Assumptions:

1. Micropiles are adequately spaced such that there are not group effects (i.e., at least 30 inches or 3 micropile diameters, whichever is greater).

2. Assume initial casing has a 7 inch outside diameter, 0.5 inch casing wall thickness, and steel with 80ksi yield stress. There is little known about the Site's corrosion potential, so it is assumed that the Site will have aggressive ground conditions. Therefore, 0.063 inches of steel loss is conservatively assumed (per Reference 1) on the outside of the casing during the design life, reducing the outside casing diameter to 6.87 inches and wall thickness to 0.44 inch.

3. Analyze only the cased section, as it will be designed to carry the lateral and moment loading. The uncased pile length will be located below the depth to zero bending moment, as the uncased length performs poorly in bending.

Calculation:

The following section documents the input parameters used in the LPile software. The software package has three primary input menus: Pile Properties, Soil Properties, and Pile Head Loading.

Pile Properties Menu

Model pile (**described in assumption 2**) as a round shaft with casing and a core/insert (#10 threadbar). No rebar cage reinforcement is used. The material properties used in this analysis are selected based on preliminary analyses as this calculation is an iterative process with multiple LPile analyses and subsequent geo/structural capacity checks.

Length of Section =	15	feet	(assumed to be long enough to extend through the overburden and into competent rock)
Casing Outside Diameter =	6.874	inches	(with corrosion reduction as stated in Assumption 2)
Casing Wall Thickness =	0.437	inches	(with corrosion reduction as stated in Assumption 2)
Core (Threadbar) Diameter =	1.43	inches	(#10 threadbar, selected based on preliminary analyses)
Core (Threadbar) Wall Thickness =	0.715	inch	(solid bar, half diameter of #10 threadbar, selected based on preliminary analyses)
Compressive Strength of Grout/Concrete =	4,000	psi	(assumed, typical for micropile design and construction)
Max. Coarse Aggregate Size =	0.75	in	(assumed, typical for micropile design and construction)
Yield Stress of Casing =	80,000	psi	(assumed, typical for micropile design and construction)
Elastic Modulus of Casing =	29,000,000	psi	(assumed, typical for micropile design and construction)
Yield Stress of Core/Insert =	75,000	psi	(assumed, typical for micropile design and construction)
Core/Insert Type =	Steel Pipe Section		

Soil Properties Menu

Define soil acting along the side of micropile in two layers: Layer 1 = Fill and Layer 2 = Bedrock. The subgrade materials are modeled in the LPile software using p-y curves which predict lateral pile response to loading. The software requires that input properties be provided for the top and bottom of soil layer to account for linear variation of properties within the layer; however, this analysis assumes material properties are consistent throughout the layer. Input properties for each of the layers are as follow:

Layer 1 - Fill

The overburden soils at the site are interpreted be fill consisting of silty sand and gravel with cobble/boulders and concrete rubble. Based on the drilling logs, it does not appear that there are appreciable voids within the fill (i.e. sudden drops of the drill string/sampling tools) and as such, from a lateral pile response perspective, we have model the layer as a granular sand/gravel fill.

p-y Curve Type =	API Sand (O'Neill)		(this model was selected as it is applicable for pipe piles in sand)
Vertical Depth Below Pile Head of Top of Soil Layer =	0	feet	(assumed, pile starts at the existing ground surface)
Top of Layer Effective Unit Weight =	125	pcf	(assumed, for a loose gravelly sand)
Top of Layer Friction Angle =	34	degrees	(assumed, for a loose gravelly sand)
Top of Layer k_1 =	Program default	pci	(the program will take the input parameters to determine the k1 value)
Vertical Depth Below Pile Head of Bottom of Soil Layer =	11	feet	(assumed, fill extends to the top of competent rock surface)
Bottom of Layer Effective Unit Weight =	125	pcf	(assumed, for a loose gravelly sand)
Bottom of Layer Friction Angle =	34	degrees	(assumed, for a loose gravelly sand)
Bottom of Layer k_1 =	Program default	pci	(the program will take the input parameters to determine the k1 value)

Layer 2 - Bedrock

Based on preliminary analyses, the bending moments within the pile occur above the bedrock surface and the bedrock does not interact significantly in the analysis. The rock itself is interpreted to be moderately strong but highly fractured; therefore, the bedrock is conservatively modeled as being weak, but providing more resistance that the overlying fill. The water table is interpreted to be at the approximate top of rock surface.

p-y Curve Type =	Weak Rock (Reese)		(this model was selected to simulate lateral pile response in weak rock)
Vertical Depth Below Pile Head of Top of Rock Layer =	11	feet	(assumed, top of competent rock surface)
Top of Layer Effective Unit Weight =	79.6	pcf	(assumed, conservatively lightweight rock below the water table)
Top of Layer Strain factor (krm) =	0.0005		LPile user manual states value typically ranges from 0.0005 to 0.00005. The selected end of the range provides a negligibly larger bending moment and was selected for design.
Top of Layer Uniaxial Compressive Strength (qu) =	100	psi	(assumed, conservatively very low strength rock)
Top of Layer Initial Modulus of Rock Mass =	106500	psi	(Reference 3, for sandstone)
RQD =	10	%	(low end range of rock quality. Measured RQD in the field was 0-66%, but generally on the low end of the range)
Vertical Depth Below Pile Head of Bottom of Rock Layer =	50	feet	(assumed, extent of rock conservatively longer than what is needed for the model)
Top of Layer Effective Unit Weight =	79.6	pcf	(assumed, conservatively lightweight rock below the water table)
Top of Layer Strain factor (krm) =	0.0005		Lpile user manual states value typically ranges from 0.0005 to 0.00005. The selected end of the range provides a negligibly larger bending moment and was selected for design.
Top of Layer Uniaxial Compressive Strength (qu) =	100	psi	(assumed, conservatively very low strength rock)
Top of Layer Initial Modulus of Rock Mass =	106500	psi	(Reference 3, for sandstone)
RQD =	10	%	(low end range of rock quality. Measured RQD in the field was 0-66%, but generally on the low end of the range)

Pile-Head Loading

Structural evaluation assumed pinned head condition. Per the LPILE software package, to specify a pinned-head condition, the shear and moment loading condition should be selected and the moment value should be set equal to zero. The following loading conditions were selected from the structural analysis.

Case 1: Maximum Axial Loading Condition

Shear Force =	2,000	pounds
Moment Force =	0	inch-pounds
Axial Load =	80,000	pounds (compression)

Case 2: Maximum Lateral Loading

Shear Force =	8,000	pounds
Moment Force =	0	inch-pounds
Axial Load =	32,500	pounds (tension)

Case 3: Large Shear/Axial Combination Load

Shear Force =	8,000	pounds
Moment Force =	0	inch-pounds
Axial Load =	80,000	pounds (compression)

Case 4: Maximum Tensile Load

Shear Force =	7,500	pounds
Moment Force =	0	inch-pounds
Axial Load =	7,000	pounds (tension)

Model Output:

Case 1: Maximum Axial Loading Condition

Pile Head Deflection =	0.07	inch
Maximum Bending Moment =	46,688	inch-pounds, @ 3.0 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	8.5	feet

Case 2: Maximum Lateral Loading

Pile Head Deflection =	0.54	inch
Maximum Bending Moment =	280,003	inch-pounds, @ 4.1 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	12.6	feet

Case 3: Large Shear/Axial Combination Load

Pile Head Deflection =	0.58	inch
Maximum Bending Moment =	303,621	inch-pounds, @ 4.1 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	13	feet

Case 4: Maximum Tensile Load

Pile Head Deflection =	0.46	inch
Maximum Bending Moment =	240,194	inch-pounds, @ 3.9 feet
Depth of Negligible Moment Load (i.e., less than 1000 inch-pounds) =	12.4	feet

Conclusion:

Based on the results of the loading cases analyzed, Case 3 has the largest bending moment and will control the buckling portion of the design. However, the maximum compression and tension loads will be used to design the uncased bond lengths.

```
================================================================================

                     LPile for Windows, Version 2019-11.009

                 Analysis of Individual Piles and Drilled Shafts
                 Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Project Files\MA-NZ\MEDMR\16667 - Woodland Fish Lift Design\Working\Geotechnical
Investigation\Design\LPile Design\Exit Flume Reactions\

Name of input data file:
Final Woodland Micropile - Pinned - 4 Cases -100424.lp11d

Name of output report file:
Final Woodland Micropile - Pinned - 4 Cases -100424.lp11o

Name of plot output file:
Final Woodland Micropile - Pinned - 4 Cases -100424.lp11p

Name of runtime message file:
Final Woodland Micropile - Pinned - 4 Cases -100424.lp11r


--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------
```

Date: December 18, 2024 Time: 11:59:09

Problem Title

Project Name: Woodland Fish Passage Design

Job Number: 16667

Client: State of Maine; Marine Resources, Bureau of Sea Run Fisheries

Engineer: Cameron J. Stuart PE

Description: Micropile Calculation - Exit Flume

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

```
Number of pile sections defined                    =            1
Total length of pile                               =       15.000 ft
Depth of ground surface below top of pile          =       0.0000 ft
```

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	6.8740
2	15.000	6.8740

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a drilled shaft with casing and pipe core
   Length of section                                  =    15.000000 ft
```

```
   Section Diameter                                        =     6.874000 in
   Shear capacity of section                               =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by API RP-2A, 1987

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =    11.000000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 pcf
   Friction angle at top of layer                          =    34.000000 deg.
   Friction angle at bottom of layer                       =    34.000000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer               =    11.000000 ft
   Distance from top of pile to bottom of layer            =    50.000000 ft
   Effective unit weight at top of layer                   =    79.600000 pcf
   Effective unit weight at bottom of layer                =    79.600000 pcf
   Uniaxial compressive strength at top of layer           =   100.000000 psi
   Uniaxial compressive strength at bottom of layer        =   100.000000 psi
   Initial modulus of rock at top of layer                 =      106500. psi
   Initial modulus of rock at bottom of layer              =      106500. psi
   RQD of rock at top of layer                             =    10.000000 %
   RQD of rock at bottom of layer                          =    10.000000 %
   k rm of rock at top of layer                            =    0.0005000
   k rm of rock at bottom of layer                         =    0.0005000
```

```
 (Depth of the lowest soil layer extends 35.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of     Uniaxial
              E50                    Rock Mass
 Num.           Name             Depth       Unit Wt.    Friction        qu
RQD %         or            kpy        Modulus
          (p-y Curve Type)        ft           pcf          deg.         psi
              krm           pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------
  1             API                 0.00     125.0000     34.0000       --
 --           --         default        --
                Sand             11.0000     125.0000     34.0000       --
 --           --         default        --
  2             Weak             11.0000      79.6000       --        100.0000
10.0000     5.00E-04       --          106500.
                Rock             50.0000      79.6000       --        100.0000
10.0000     5.00E-04       --          106500.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 4

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =        2000. lbs   M =       0.0000 in-lbs           80000.
    No               Yes
```

```
   2     1     V =        8000. lbs   M =       0.0000 in-lbs           32500.
    No                Yes
   3     1     V =        8000. lbs   M =       0.0000 in-lbs           80000.
    No                Yes
   4     1     V =        7500. lbs   M =       0.0000 in-lbs           -7000.
    No                Yes
```

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and Pipe Core:

Length of Section	=	15.000000 ft
Outside Diameter of Casing	=	6.874000 in
Casing Wall Thickness	=	0.437000 in
Moment of Inertia of Steel Casing	=	45.982107 in^4
Outside Diameter of Core	=	1.430000 in
Core Wall Thickness	=	0.715000 in
Moment of Inertia of Steel Core/Insert	=	0.205265 in^4
Yield Stress of Casing	=	80000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	75000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Gross Area of Pile	=	37.111537 sq. in.
Area of Concrete	=	26.668273 sq. in.
Cross-sectional Area of Steel Casing	=	8.837203 sq. in.
Cross-sectional Area of Steel Core/Insert	=	1.606061 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	10.443263 sq. in.
Area Ratio of All Steel to Gross Area	=	28.14 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	918.103 kips
Tensile Load for Cracking of Concrete	=	-46.032 kips
Nominal Axial Tensile Capacity	=	-827.431 kips

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

Number	Axial Thrust Force kips
1	-7.000
2	32.500
3	80.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = -7.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
0.00000125	2.0075795	1606064.	-10.0424372	-0.00001255	-0.00002115	-0.0532435	0.00000	-0.6119749	-0.5147938	
0.00000250	4.0151587	1606063.	-3.3030408	-0.00000826	-0.00002544	-0.0353081	0.00000	-0.7353436	-0.5409813	
0.00000375	6.0227374	1606063.	-1.0567185	-0.00000396	-0.00002974	-0.0173343	0.00000	-0.8587279	-0.5671844	
0.00000500	8.0303152	1606063.	0.0663352	3.31676E-07	-0.00003404	0.0006778	0.00000	-0.9821277	-0.5934030	
0.00000625	10.0378889	1606062.	0.7400820	0.00000463	-0.00003834	0.0186847	0.00000	-1.1055431	-0.6196372	
0.00000750	12.0453729	1606050.	1.1891852	0.00000892	-0.00004264	0.0366489	0.00000	-1.2289717	-0.6458847	
0.00000875	14.0526182	1606014.	1.5099372	0.00001321	-0.00004694	0.0545713	0.00000	-1.3524095	-0.6721413	
0.00001000	16.0595342	1605953.	1.7504801	0.00001750	-0.00005124	0.0724521	0.00000	-1.4758534	-0.6984040	
0.00001125	18.0660715	1605873.	1.9375559	0.00002180	-0.00005553	0.0902917	0.00000	-1.5993016	-0.7246711	
0.00001250	20.0722024	1605776.	2.0872081	0.00002609	-0.00005983	0.1080903	0.00000	-1.7227529	-0.7509412	
0.00001375	22.0779107	1605666.	2.2096451	0.00003038	-0.00006413	0.1258479	0.00000	-1.8462064	-0.7772135	
0.00001500	24.0831860	1605546.	2.3116720	0.00003468	-0.00006843	0.1435646	0.00000	-1.9696617	-0.8034876	
0.00001625	26.0880220	1605417.	2.3979995	0.00003897	-0.00007274	0.1612406	0.00000	-2.0931183	-0.8297630	
0.00001750	28.0924142	1605281.	2.4719925	0.00004326	-0.00007704	0.1788758	0.00000	-2.2165760	-0.8560395	
0.00001875	30.0963598	1605139.	2.5361182	0.00004755	-0.00008134	0.1964703	0.00000	-2.3400345	-0.8823169	
0.00002000	32.0998566	1604993.	2.5922269	0.00005184	-0.00008564	0.2140241	0.00000	-2.4634937	-0.9085949	
0.00002125	34.1029030	1604842.	2.6417337	0.00005614	-0.00008994	0.2315372	0.00000	-2.5869535	-0.9348735	
0.00002250	36.1054981	1604689.	2.6857390	0.00006043	-0.00009424	0.2490097	0.00000	-2.7104138	-0.9611527	
0.00002375	38.1076409	1604532.	2.7251116	0.00006472	-0.00009854	0.2664414	0.00000	-2.8338745	-0.9874322	
0.00002500	40.1093309	1604373.	2.7605464	0.00006901	-0.0001028	0.2838326	0.00000	-2.9573356	-1.0137121	

0.00002625	42.1105676	1604212.	2.7926060	0.00007331	-0.0001071
0.3011831	0.00000	-3.0807969	-1.0399922		
0.00002750	44.1113506	1604049.	2.8217509	0.00007760	-0.0001114
0.3184929	0.00000	-3.2042585	-1.0662727		
0.00002875	44.1113506	1534308.	2.5275238	0.00007267	-0.0001250
0.2982235	0.00000	-3.5952185	-1.3600515 C		
0.00003000	44.1113506	1470378.	2.5574096	0.00007672	-0.0001295
0.3145786	0.00000	-3.7255317	-1.3931835 C		
0.00003125	44.1113506	1411563.	2.5848776	0.00008078	-0.0001340
0.3308940	0.00000	-3.8558693	-1.4263399 C		
0.00003250	45.9149302	1412767.	2.6101484	0.00008483	-0.0001386
0.3471621	0.00000	-3.9862863	-1.4595757 C		
0.00003375	47.7322843	1414290.	2.6335549	0.00008888	-0.0001431
0.3633951	0.00000	-4.1166959	-1.4928042 C		
0.00003500	49.5497777	1415708.	2.6552535	0.00009293	-0.0001477
0.3795868	0.00000	-4.2471424	-1.5260695 C		
0.00003625	51.3675404	1417036.	2.6754034	0.00009698	-0.0001522
0.3957348	0.00000	-4.3776434	-1.5593893 C		
0.00003750	53.1851351	1418270.	2.6942168	0.0001010	-0.0001567
0.4118478	0.00000	-4.5081371	-1.5927018 C		
0.00003875	55.0025622	1419421.	2.7118230	0.0001051	-0.0001613
0.4279257	0.00000	-4.6386230	-1.6260066 C		
0.00004000	56.8202764	1420507.	2.7282718	0.0001091	-0.0001658
0.4439583	0.00000	-4.7691757	-1.6593781 C		
0.00004125	58.6379385	1421526.	2.7437144	0.0001132	-0.0001704
0.4599534	0.00000	-4.8997392	-1.6927604 C		
0.00004250	60.4554327	1422481.	2.7582546	0.0001172	-0.0001749
0.4759134	0.00000	-5.0302953	-1.7261354 C		
0.00004375	62.2727590	1423377.	2.7719698	0.0001213	-0.0001795
0.4918384	0.00000	-5.1608441	-1.7595029 C		
0.00004500	64.0899473	1424221.	2.7849243	0.0001253	-0.0001840
0.5077275	0.00000	-5.2913910	-1.7928687 C		
0.00004625	65.9073340	1425023.	2.7971337	0.0001294	-0.0001886
0.5235724	0.00000	-5.4219983	-1.8262949 C		
0.00004750	67.7245530	1425780.	2.8087057	0.0001334	-0.0001931
0.5393822	0.00000	-5.5525983	-1.8597137 C		
0.00004875	69.5416043	1426494.	2.8196895	0.0001375	-0.0001976
0.5551570	0.00000	-5.6831909	-1.8931251 C		
0.00005125	73.1752036	1427809.	2.8400647	0.0001456	-0.0002067
0.5866015	0.00000	-5.9443540	-1.9599258 C		
0.00005375	76.8083096	1428992.	2.8585385	0.0001536	-0.0002158
0.6179006	0.00000	-6.2055264	-2.0267359 C		
0.00005625	80.4411119	1430064.	2.8753392	0.0001617	-0.0002249
0.6490487	0.00000	-6.4667494	-2.0935965 C		
0.00005875	84.0732434	1431034.	2.8907274	0.0001698	-0.0002340
0.6800567	0.00000	-6.7279429	-2.1604276 C		
0.00006125	87.7047037	1431914.	2.9048759	0.0001779	-0.0002431
0.7109244	0.00000	-6.9891069	-2.2272294 C		
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0.7416519	0.00000	-7.2502414	-2.2940014 C		

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0.00006625   94.9658656     1433447.    2.9299803    0.0001941    -0.0002613
0.7722301     0.00000    -7.5114145    -2.3608122 C
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0.00007125  102.2248010     1434734.    2.9515594    0.0002103    -0.0002795
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0.8931254     0.00000    -8.5559195    -2.6278678 C
0.00007875  113.1081615     1436294.    2.9788868    0.0002346    -0.0003067
0.9229982     0.00000    -8.8169721    -2.6945581 C
0.00008125  116.7346024     1436734.    2.9868999    0.0002427    -0.0003158
0.9527304     0.00000    -9.0779951    -2.7612187 C
0.00008375  120.3604932     1437140.    2.9944295    0.0002508    -0.0003249
0.9823166     0.00000    -9.3390305    -2.8278918 C
0.00008625  123.9858042     1437517.    3.0015220    0.0002589    -0.0003340
1.0117584     0.00000    -9.6000676    -2.8945665 C
0.00008875  127.6104414     1437864.    3.0082263    0.0002670    -0.0003431
1.0410595     0.00000    -9.8610753    -2.9612118 C
0.00009125  131.2344045     1438185.    3.0145743    0.0002751    -0.0003522
1.0702200     0.00000   -10.1220535    -3.0278277 C
0.00009375  134.8576929     1438482.    3.0205947    0.0002832    -0.0003613
1.0992397     0.00000   -10.3830022    -3.0944141 C
0.00009625  138.4803063     1438756.    3.0263128    0.0002913    -0.0003703
1.1281186     0.00000   -10.6439215    -3.1609710 C
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1.1568567     0.00000   -10.9048112    -3.2274984 C
 0.0001013  145.7235061     1439245.    3.0369321    0.0003075    -0.0003885
1.1854539     0.00000   -11.1656715    -3.2939963 C
 0.0001038  149.3440917     1439461.    3.0418727    0.0003156    -0.0003976
1.2139101     0.00000   -11.4265021    -3.3604646 C
 0.0001063  152.9640005     1439661.    3.0465904    0.0003237    -0.0004067
1.2422254     0.00000   -11.6873033    -3.4269034 C
 0.0001088  156.5832320     1439846.    3.0511005    0.0003318    -0.0004157
1.2703996     0.00000   -11.9480748    -3.4933126 C
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1.2984327     0.00000   -12.2088167    -3.5596921 C
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 0.0001163  167.4369950     1440318.    3.0635016    0.0003561    -0.0004430
1.3540682     0.00000   -12.7302728    -3.6924235 C
 0.0001188  171.0536320     1440452.    3.0672949    0.0003642    -0.0004520
1.3816714     0.00000   -12.9909789    -3.7587673 C
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1.4091334     0.00000   -13.2516555    -3.8250816 C
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1.4364541     0.00000   -13.5123025    -3.8913662 C
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1.4636334     0.00000   -13.7729199    -3.9576212 C
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1.4906713	0.00000	-14.0335077	-4.0238466 C		
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0.0001488	214.4002158	1441346.	3.1034050	0.0004616	-0.0005609
1.7018771	0.00000	-16.1171402	-4.5525803 C		
0.0001588	228.8272291	1441431.	3.1126158	0.0004941	-0.0005971
1.8040763	0.00000	-17.1582412	-4.8162319 C		
0.0001688	243.2432713	1441442.	3.1208328	0.0005266	-0.0006333
1.9040017	0.00000	-18.1988634	-5.0794048 C		
0.0001788	257.6483307	1441389.	3.1282209	0.0005592	-0.0006696
2.0016488	0.00000	-19.2390168	-5.3421087 C		
0.0001888	272.0425653	1441285.	3.1348898	0.0005917	-0.0007058
2.0970019	0.00000	-20.2788215	-5.6044641 C		
0.0001988	286.4257514	1441136.	3.1409710	0.0006243	-0.0007419
2.1900715	0.00000	-21.3181453	-5.8663385 C		
0.0002088	300.7978602	1440948.	3.1465493	0.0006568	-0.0007781
2.2808540	0.00000	-22.3569867	-6.1277305 C		
0.0002188	315.1588626	1440726.	3.1516939	0.0006894	-0.0008143
2.3693460	0.00000	-23.3953444	-6.3886387 C		
0.0002288	329.5087296	1440475.	3.1564618	0.0007220	-0.0008504
2.4555440	0.00000	-24.4332167	-6.6490617 C		
0.0002388	343.8474321	1440199.	3.1609006	0.0007547	-0.0008865
2.5394444	0.00000	-25.4706023	-6.9089979 C		
0.0002488	358.1749405	1439899.	3.1650502	0.0007873	-0.0009226
2.6210439	0.00000	-26.5074997	-7.1684459 C		
0.0002588	372.4912255	1439580.	3.1689443	0.0008200	-0.0009587
2.7003387	0.00000	-27.5439074	-7.4274042 C		
0.0002688	386.7962572	1439242.	3.1726116	0.0008526	-0.0009947
2.7773253	0.00000	-28.5798240	-7.6858714 C		
0.0002788	401.0900059	1438888.	3.1760767	0.0008853	-0.0010308
2.8520003	0.00000	-29.6152479	-7.9438459 C		
0.0002888	415.3724417	1438519.	3.1793609	0.0009180	-0.0010668
2.9243599	0.00000	-30.6501777	-8.2013263 C		
0.0002988	429.6435343	1438137.	3.1824824	0.0009508	-0.0011028
2.9944005	0.00000	-31.6846118	-8.4583110 C		
0.0003088	443.9032535	1437743.	3.1854572	0.0009835	-0.0011388
3.0621186	0.00000	-32.7185487	-8.7147985 C		

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 0.0003188   458.1515689     1437338.    3.1882993     0.0010163    -0.0011748
3.1275105      0.00000   -33.7519869    -8.9707873 C
 0.0003288   472.3884499     1436923.    3.1910210     0.0010490    -0.0012108
3.1905726      0.00000   -34.7849249    -9.2262759 C
 0.0003388   486.6138657     1436498.    3.1936331     0.0010818    -0.0012467
3.2513011      0.00000   -35.8173611    -9.4812627 C
 0.0003488   500.8277855     1436065.    3.1961451     0.0011147    -0.0012827
3.3096924      0.00000   -36.8492939    -9.7357461 C
 0.0003588   515.0302689     1435624.    3.1985572     0.0011475    -0.0013186
3.3657375      0.00000   -37.8808102    -9.9898130 C
 0.0003688   529.2212109     1435176.    3.2008846     0.0011803    -0.0013545
3.4194378      0.00000   -38.9118326   -10.2433860 C
 0.0003788   543.4005693     1434721.    3.2031352     0.0012132    -0.0013903
3.4707900      0.00000   -39.9423492   -10.4964532 C
 0.0003888   557.5683129     1434259.    3.2053149     0.0012461    -0.0014262
3.5197905      0.00000   -40.9723583   -10.7490129 C
 0.0003988   571.7244099     1433792.    3.2074294     0.0012790    -0.0014620
3.5664354      0.00000   -42.0018584   -11.0010636 C
 0.0004088   585.8688288     1433318.    3.2094835     0.0013119    -0.0014979
3.6107210      0.00000   -43.0308479   -11.2526037 C
 0.0004188   600.0015375     1432839.    3.2114817     0.0013448    -0.0015337
3.6526435      0.00000   -44.0593252   -11.5036315 C
 0.0004288   614.1225040     1432356.    3.2134279     0.0013778    -0.0015695
3.6921991      0.00000   -45.0872886   -11.7541456 C
 0.0004388   628.2316961     1431867.    3.2153260     0.0014107    -0.0016052
3.7293839      0.00000   -46.1147366   -12.0041442 C
 0.0004488   642.3290814     1431374.    3.2171792     0.0014437    -0.0016410
3.7641940      0.00000   -47.1416676   -12.2536258 C
 0.0004588   656.4146273     1430877.    3.2189906     0.0014767    -0.0016767
3.7966257      0.00000   -48.1680798   -12.5025886 C
 0.0004688   670.4883010     1430375.    3.2207630     0.0015097    -0.0017125
3.8266750      0.00000   -49.1939717   -12.7510311 C
 0.0004788   684.5500697     1429870.    3.2224990     0.0015428    -0.0017482
3.8543381      0.00000   -50.2193416   -12.9989516 C
 0.0004888   698.5999002     1429360.    3.2242008     0.0015758    -0.0017838
3.8796108      0.00000   -51.2441879   -13.2463485 C
 0.0004988   712.6377592     1428848.    3.2258708     0.0016089    -0.0018195
3.9024895      0.00000   -52.2685088   -13.4932200 C
 0.0005088   726.6636133     1428331.    3.2275108     0.0016420    -0.0018552
3.9229700      0.00000   -53.2923027   -13.7395645 C
 0.0005188   740.6774289     1427812.    3.2291227     0.0016751    -0.0018908
3.9410484      0.00000   -54.3155679   -13.9853803 C
 0.0005288   754.6791722     1427289.    3.2307082     0.0017082    -0.0019264
3.9567206      0.00000   -55.3383027   -14.2306656 C
 0.0005388   768.6688091     1426763.    3.2322690     0.0017414    -0.0019620
3.9699828      0.00000   -56.3605053   -14.4754189 C
 0.0005488   782.6463055     1426235.    3.2338064     0.0017746    -0.0019976
3.9808307      0.00000   -57.3821741   -14.7196383 C
 0.0006088   866.2543961     1423005.    3.2426106     0.0019739    -0.0022106
3.9996772      0.00000   -63.5008786   -16.1736464 C
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    0.0006688   949.4166067      1419688.     3.2508490     0.0021740    -0.0024230
   3.9998622       0.00000   -69.5999197   -17.6079911 C
    0.0007288          1032.      1416275.     3.2587012     0.0023748    -0.0026346
   3.9984206       0.00000   -75.6784525   -19.0218274 C
    0.0007888          1114.      1412224.     3.2657543     0.0025759    -0.0028460
   3.9979828       0.00000   -80.0000000   -20.4266163 CY
    0.0008488          1187.      1398842.     3.2638855     0.0027702    -0.0030641
   3.9995337       0.00000   -80.0000000   -22.0264624 CY
    0.0009088          1245.      1370033.     3.2518892     0.0029552    -0.0032916
   3.9993363       0.00000    80.0000000   -23.8997129 CY
    0.0009688          1288.      1329786.     3.2402578     0.0031390    -0.0035202
   3.9976404       0.00000    80.0000000   -25.8044717 CY
    0.0010288          1320.      1283442.     3.2332862     0.0033262    -0.0037454
   3.9998940       0.00000    80.0000000   -27.6106497 CY
    0.0010888          1345.      1235799.     3.2291027     0.0035157    -0.0039684
   3.9966607       0.00000    80.0000000   -29.3530790 CY
    0.0011488          1366.      1188954.     3.2264472     0.0037064    -0.0041901
   3.9985777       0.00000    80.0000000   -31.0591647 CY
    0.0012088          1383.      1143869.     3.2247953     0.0038980    -0.0044110
   3.9993529       0.00000    80.0000000   -32.7393186 CY


Axial Thrust Force =     32.500 kips

    Bending        Bending        Bending        Depth to      Max Comp       Max Tens
  Max Conc       Max Steel     Max Casing     Max Core     Run
   Curvature        Moment       Stiffness       N Axis         Strain         Strain
   Stress         Stress         Stress         Stress     Msg
    rad/in.        in-kip        kip-in2           in          in/in          in/in
     ksi            ksi            ksi            ksi
------------- ------------- ------------- ------------- ------------- -------------
------------- ------------- ------------- ------------- ---
   0.00000125     1.9965760      1597261.    66.2993474    0.00008287    0.00007428
   0.3435882       0.00000     2.4021054     2.3049243
   0.00000250     3.9931518      1597261.    34.8684988    0.00008717    0.00006999
   0.3608179       0.00000     2.5254743     2.3311120
   0.00000375     5.9897270      1597261.    24.3916937    0.00009147    0.00006569
   0.3780092       0.00000     2.6488590     2.3573154
   0.00000500     7.9863013      1597260.    19.1533996    0.00009577    0.00006140
   0.3951619       0.00000     2.7722593     2.3835346
   0.00000625     9.9828744      1597260.    16.0105098     0.0001001    0.00005710
   0.4122761       0.00000     2.8956753     2.4097695
   0.00000750    11.9794461      1597259.    13.9153221     0.0001044    0.00005281
   0.4293517       0.00000     3.0191071     2.4360201
   0.00000875    13.9760161      1597259.    12.4188215     0.0001087    0.00004852
   0.4463887       0.00000     3.1425544     2.4622861
   0.00001000    15.9725840      1597258.    11.2965001     0.0001130    0.00004423
   0.4633872       0.00000     3.2660176     2.4885682
   0.00001125    17.9691496      1597258.    10.4236317     0.0001173    0.00003993
   0.4803471       0.00000     3.3894965     2.5148659
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0.00001250	19.9657126	1597257.	9.7253803	0.0001216	0.00003564
0.4972684	0.00000	3.5129911	2.5411794		
0.00001375	21.9622727	1597256.	9.1541231	0.0001259	0.00003135
0.5141510	0.00000	3.6365014	2.5675085		
0.00001500	23.9588297	1597255.	8.6781116	0.0001302	0.00002706
0.5309950	0.00000	3.7600275	2.5938534		
0.00001625	25.9553831	1597254.	8.2753660	0.0001345	0.00002277
0.5478003	0.00000	3.8835693	2.6202140		
0.00001750	27.9519328	1597253.	7.9301864	0.0001388	0.00001848
0.5645670	0.00000	4.0071267	2.6465903		
0.00001875	29.9484784	1597252.	7.6310596	0.0001431	0.00001419
0.5812950	0.00000	4.1306999	2.6729823		
0.00002000	31.9450197	1597251.	7.3693508	0.0001474	0.00000991
0.5979842	0.00000	4.2542888	2.6993900		
0.00002125	33.9415563	1597250.	7.1384567	0.0001517	0.00000562
0.6146348	0.00000	4.3778934	2.7258135		
0.00002250	35.9380880	1597248.	6.9332417	0.0001560	0.00000133
0.6312466	0.00000	4.5015138	2.7522526		
0.00002375	37.9346145	1597247.	6.7496510	0.0001603	-0.00000295
0.6478196	0.00000	4.6251498	2.7787075		
0.00002500	39.9311355	1597245.	6.5844411	0.0001646	-0.00000724
0.6643539	0.00000	4.7488015	2.8051780		
0.00002625	41.9276507	1597244.	6.4349861	0.0001689	-0.00001152
0.6808494	0.00000	4.8724690	2.8316643		
0.00002750	43.9241557	1597242.	6.2991375	0.0001732	-0.00001581
0.6973061	0.00000	4.9961521	2.8581662		
0.00002875	45.9206245	1597239.	6.1751197	0.0001775	-0.00002009
0.7137239	0.00000	5.1198501	2.8846831		
0.00003000	47.9170174	1597234.	6.0614529	0.0001818	-0.00002438
0.7301026	0.00000	5.2435622	2.9112140		
0.00003125	49.9132932	1597225.	5.9568937	0.0001862	-0.00002866
0.7464421	0.00000	5.3672871	2.9377578		
0.00003250	51.9094144	1597213.	5.8603901	0.0001905	-0.00003294
0.7627422	0.00000	5.4910240	2.9643134		
0.00003375	53.9053458	1597195.	5.7710460	0.0001948	-0.00003722
0.7790029	0.00000	5.6147717	2.9908800		
0.00003500	55.9010572	1597173.	5.6880935	0.0001991	-0.00004151
0.7952239	0.00000	5.7385294	3.0174565		
0.00003625	57.8965218	1597145.	5.6108705	0.0002034	-0.00004579
0.8114051	0.00000	5.8622963	3.0440422		
0.00003750	59.8917159	1597112.	5.5388035	0.0002077	-0.00005007
0.8275465	0.00000	5.9860716	3.0706363		
0.00003875	61.8866188	1597074.	5.4713929	0.0002120	-0.00005435
0.8436479	0.00000	6.1098546	3.0972382		
0.00004000	63.8812127	1597030.	5.4082015	0.0002163	-0.00005863
0.8597093	0.00000	6.2336447	3.1238471		
0.00004125	65.8754818	1596981.	5.3488455	0.0002206	-0.00006291
0.8757306	0.00000	6.3574414	3.1504626		
0.00004250	67.8694125	1596927.	5.2929859	0.0002250	-0.00006719
0.8917117	0.00000	6.4812442	3.1770842		

0.00004375	69.8629926	1596868.	5.2403226	0.0002293	-0.00007147
0.9076525	0.00000	6.6050526	3.2037114		
0.00004500	71.8562111	1596805.	5.1905892	0.0002336	-0.00007575
0.9235530	0.00000	6.7288661	3.2303438		
0.00004625	73.8490591	1596736.	5.1435476	0.0002379	-0.00008003
0.9394131	0.00000	6.8526845	3.2569811		
0.00004750	75.8415288	1596664.	5.0989851	0.0002422	-0.00008431
0.9552329	0.00000	6.9765075	3.2836228		
0.00004875	77.8336118	1596587.	5.0567109	0.0002465	-0.00008859
0.9710121	0.00000	7.1003346	3.3102688		
0.00005125	81.8165952	1596421.	4.9783567	0.0002551	-0.00009715
1.0024492	0.00000	7.3480004	3.3635722		
0.00005375	85.7979656	1596241.	4.9073001	0.0002638	-0.0001057
1.0337238	0.00000	7.5956789	3.4168884		
0.00005625	89.7776876	1596048.	4.8425670	0.0002724	-0.0001143
1.0648362	0.00000	7.8433714	3.4702185		
0.00005875	91.1842228	1552072.	4.7363350	0.0002783	-0.0001256
1.0857954	0.00000	8.0109730	3.4434578 C		
0.00006125	94.8570649	1548687.	4.6779904	0.0002865	-0.0001345
1.1153370	0.00000	8.2482309	3.4863534 C		
0.00006375	98.5234503	1545466.	4.6240678	0.0002948	-0.0001434
1.1446929	0.00000	8.4852039	3.5289640 C		
0.00006625	102.1841484	1542402.	4.5740838	0.0003030	-0.0001524
1.1738677	0.00000	8.7219254	3.5713231 C		
0.00006875	105.8379821	1539462.	4.5275655	0.0003113	-0.0001613
1.2028514	0.00000	8.9583087	3.6133441 C		
0.00007125	109.4881683	1536676.	4.4842371	0.0003195	-0.0001703
1.2316669	0.00000	9.1945381	3.6552112 C		
0.00007375	113.1342423	1534024.	4.4437597	0.0003277	-0.0001792
1.2603108	0.00000	9.4305824	3.6968931 C		
0.00007625	116.7756101	1531483.	4.4058286	0.0003359	-0.0001882
1.2887771	0.00000	9.6663881	3.7383365 C		
0.00007875	120.4148819	1529078.	4.3702784	0.0003442	-0.0001972
1.3170872	0.00000	9.9021310	3.7797170 C		
0.00008125	124.0493479	1526761.	4.3368040	0.0003524	-0.0002061
1.3452173	0.00000	10.1376103	3.8208339 C		
0.00008375	127.6823662	1524566.	4.3053187	0.0003606	-0.0002151
1.3731964	0.00000	10.3730670	3.8619282 C		
0.00008625	131.3116571	1522454.	4.2755781	0.0003688	-0.0002241
1.4010036	0.00000	10.6083221	3.9028210 C		
0.00008875	134.9389532	1520439.	4.2474864	0.0003770	-0.0002331
1.4286547	0.00000	10.8435085	3.9436451 C		
0.00009125	138.5645871	1518516.	4.2209155	0.0003852	-0.0002421
1.4561524	0.00000	11.0786464	3.9844206 C		
0.00009375	142.1866662	1516658.	4.1956866	0.0003933	-0.0002511
1.4834781	0.00000	11.3135773	4.0249892 C		
0.00009625	145.8080511	1514889.	4.1717792	0.0004015	-0.0002601
1.5106602	0.00000	11.5485414	4.0655909 C		
0.00009875	149.4273270	1513188.	4.1490490	0.0004097	-0.0002691
1.5376839	0.00000	11.7834122	4.1060994 C		

0.0001013	153.0440430	1511546.	4.1273954	0.0004179	-0.0002781
1.5645444	0.00000	12.0181442	4.1464691 C		
0.0001038	156.6600629	1509977.	4.1067954	0.0004261	-0.0002871
1.5912611	0.00000	12.2529086	4.1868710 C		
0.0001063	160.2750019	1508471.	4.0871626	0.0004343	-0.0002961
1.6178300	0.00000	12.4876676	4.2272677 C		
0.0001088	163.8870367	1507007.	4.0683746	0.0004424	-0.0003051
1.6442306	0.00000	12.7222410	4.2674788 C		
0.0001113	167.4983742	1505603.	4.0504404	0.0004506	-0.0003141
1.6704877	0.00000	12.9568461	4.3077215 C		
0.0001138	171.1090105	1504255.	4.0333035	0.0004588	-0.0003231
1.6966010	0.00000	13.1914811	4.3479942 C		
0.0001163	174.7183819	1502954.	4.0168949	0.0004670	-0.0003321
1.7225639	0.00000	13.4260875	4.3882382 C		
0.0001188	178.3255286	1501689.	4.0011392	0.0004751	-0.0003412
1.7483650	0.00000	13.6605606	4.4283490 C		
0.0001213	181.9319764	1500470.	3.9860416	0.0004833	-0.0003502
1.7740226	0.00000	13.8950648	4.4684908 C		
0.0001238	185.5377227	1499295.	3.9715625	0.0004915	-0.0003592
1.7995363	0.00000	14.1295989	4.5086626 C		
0.0001263	189.1427669	1498161.	3.9576649	0.0004997	-0.0003682
1.8249063	0.00000	14.3641630	4.5488643 C		
0.0001288	192.7460665	1497057.	3.9442824	0.0005078	-0.0003772
1.8501192	0.00000	14.5986351	4.5889741 C		
0.0001313	196.3480297	1495985.	3.9313981	0.0005160	-0.0003862
1.8751805	0.00000	14.8330628	4.6290394 C		
0.0001338	199.9492910	1494948.	3.9190031	0.0005242	-0.0003952
1.9000980	0.00000	15.0675203	4.6691346 C		
0.0001363	203.5498499	1493944.	3.9070705	0.0005323	-0.0004042
1.9248716	0.00000	15.3020077	4.7092597 C		
0.0001388	207.1497059	1492971.	3.8955754	0.0005405	-0.0004133
1.9495015	0.00000	15.5365251	4.7494147 C		
0.0001413	210.7488587	1492027.	3.8844945	0.0005487	-0.0004223
1.9739873	0.00000	15.7710724	4.7895996 C		
0.0001438	214.3460628	1491103.	3.8737671	0.0005569	-0.0004313
1.9983124	0.00000	16.0054868	4.8296517 C		
0.0001463	217.9424806	1490205.	3.8634110	0.0005650	-0.0004403
2.0224925	0.00000	16.2399201	4.8697227 C		
0.0001488	221.5381953	1489332.	3.8534099	0.0005732	-0.0004493
2.0465287	0.00000	16.4743834	4.9098236 C		
0.0001588	235.9140139	1486073.	3.8166205	0.0006059	-0.0004854
2.1412337	0.00000	17.4125358	5.0705265 C		
0.0001688	250.2746272	1483109.	3.7841703	0.0006386	-0.0005214
2.2335756	0.00000	18.3505853	5.2311267 C		
0.0001788	264.6237644	1480413.	3.7554382	0.0006713	-0.0005574
2.3236078	0.00000	19.2890877	5.3921797 C		
0.0001888	278.9595629	1477931.	3.7297753	0.0007040	-0.0005935
2.4112977	0.00000	20.2277252	5.5533678 C		
0.0001988	293.2829783	1475638.	3.7067472	0.0007367	-0.0006295
2.4966592	0.00000	21.1666645	5.7148576 C		

0.0002088	307.5950395	1473509.	3.6860053	0.0007695	-0.0006655	2.5797058	0.00000	22.1060878	5.8768315	C
0.0002188	321.8944831	1471518.	3.6671967	0.0008022	-0.0007015	2.6604128	0.00000	23.0457451	6.0390395	C
0.0002288	336.1815759	1469646.	3.6500767	0.0008350	-0.0007375	2.7387832	0.00000	23.9856946	6.2015396	C
0.0002388	350.4572475	1467884.	3.6344613	0.0008677	-0.0007734	2.8148304	0.00000	24.9261326	6.3645282	C
0.0002488	364.7214680	1466217.	3.6201693	0.0009005	-0.0008094	2.8885508	0.00000	25.8670603	6.5280065	C
0.0002588	378.9740015	1464634.	3.6070406	0.0009333	-0.0008453	2.9599370	0.00000	26.8084275	6.6919243	C
0.0002688	393.2137960	1463121.	3.5949121	0.0009661	-0.0008813	3.0289670	0.00000	27.7499757	6.8560231	C
0.0002788	407.4420683	1461676.	3.5837150	0.0009990	-0.0009172	3.0956613	0.00000	28.6920187	7.0206167	C
0.0002888	421.6587876	1460290.	3.5733528	0.0010318	-0.0009531	3.1600162	0.00000	29.6345579	7.1857064	C
0.0002988	435.8639231	1458959.	3.5637417	0.0010647	-0.0009889	3.2220281	0.00000	30.5775947	7.3512939	C
0.0003088	450.0574440	1457676.	3.5548089	0.0010975	-0.0010248	3.2816933	0.00000	31.5211308	7.5173805	C
0.0003188	464.2393190	1456437.	3.5464908	0.0011304	-0.0010606	3.3390082	0.00000	32.4651675	7.6839679	C
0.0003288	478.4093664	1455238.	3.5387261	0.0011634	-0.0010965	3.3939661	0.00000	33.4096558	7.8510068	C
0.0003388	492.5670413	1454072.	3.5314481	0.0011963	-0.0011323	3.4465541	0.00000	34.3544219	8.0183235	C
0.0003488	506.7129923	1452940.	3.5246375	0.0012292	-0.0011681	3.4967821	0.00000	35.2996944	8.1861466	C
0.0003588	520.8471878	1451839.	3.5182555	0.0012622	-0.0012039	3.5446462	0.00000	36.2454747	8.3544775	C
0.0003688	534.9695958	1450765.	3.5122672	0.0012951	-0.0012396	3.5901427	0.00000	37.1917645	8.5233178	C
0.0003788	549.0801842	1449717.	3.5066417	0.0013281	-0.0012754	3.6332677	0.00000	38.1385653	8.6926692	C
0.0003888	563.1789209	1448692.	3.5013510	0.0013612	-0.0013111	3.6740176	0.00000	39.0858787	8.8625333	C
0.0003988	577.2657734	1447688.	3.4963702	0.0013942	-0.0013468	3.7123883	0.00000	40.0337063	9.0329115	C
0.0004088	591.3407091	1446705.	3.4916766	0.0014272	-0.0013825	3.7483761	0.00000	40.9820498	9.2038055	C
0.0004188	605.4036953	1445740.	3.4872498	0.0014603	-0.0014182	3.7819772	0.00000	41.9309106	9.3752170	C
0.0004288	619.4546991	1444792.	3.4830713	0.0014934	-0.0014539	3.8131875	0.00000	42.8802906	9.5471476	C
0.0004388	633.4936874	1443860.	3.4791241	0.0015265	-0.0014895	3.8420033	0.00000	43.8301912	9.7195988	C
0.0004488	647.5206269	1442943.	3.4753930	0.0015596	-0.0015251	3.8684206	0.00000	44.7806142	9.8925724	C

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  0.0004588   661.5354842      1442039.    3.4718639     0.0015927    -0.0015607
 3.8924354       0.00000   45.7315611   10.0660699 C
  0.0004688   675.5379486      1441148.    3.4685130     0.0016259    -0.0015963
 3.9140406       0.00000   46.6828822   10.2399415 C
  0.0004788   689.5282269      1440268.    3.4653382     0.0016590    -0.0016319
 3.9332357       0.00000   47.6347063   10.4143163 C
  0.0004888   703.5063326      1439399.    3.4623308     0.0016922    -0.0016675
 3.9500173       0.00000   48.5870611   10.5892216 C
  0.0004988   717.4722315      1438541.    3.4594808     0.0017254    -0.0017030
 3.9643814       0.00000   49.5399481   10.7646592 C
  0.0005088   731.4258892      1437692.    3.4567791     0.0017586    -0.0017385
 3.9763240       0.00000   50.4933690   10.9406308 C
  0.0005188   745.3672711      1436853.    3.4542171     0.0017919    -0.0017740
 3.9858410       0.00000   51.4473257   11.1171381 C
  0.0005288   759.2963424      1436021.    3.4517870     0.0018251    -0.0018095
 3.9929283       0.00000   52.4018199   11.2941829 C
  0.0005388   773.2130681      1435198.    3.4494817     0.0018584    -0.0018450
 3.9975817       0.00000   53.3568533   11.4717668 C
  0.0005488   787.1174132      1434383.    3.4472944     0.0018917    -0.0018804
 3.9997973       0.00000   54.3124276   11.6498917 C
  0.0006088   870.2814955      1429621.    3.4363289     0.0020919    -0.0020927
 3.9993221       0.00000  -60.0810257  -12.7537935 C
  0.0006688   952.9833620      1425022.    3.4283703     0.0022927    -0.0023043
 3.9989705       0.00000  -66.1571151  -14.1651864 C
  0.0007288         1035.      1420522.    3.4227121     0.0024943    -0.0025151
 3.9996297       0.00000  -72.2122868  -15.5556618 C
  0.0007888         1117.      1416175.    3.4187540     0.0026965    -0.0027253
 3.9989802       0.00000  -78.2482606  -16.9269391 C
  0.0008488         1195.      1407764.    3.4148531     0.0028984    -0.0029360
 3.9999106       0.00000   80.0000000  -18.3105812 CY
  0.0009088         1255.      1381135.    3.4098980     0.0030987    -0.0031480
 3.9999642       0.00000   80.0000000  -19.7355827 CY
  0.0009688         1297.      1338519.    3.4054631     0.0032990    -0.0033601
 3.9995961       0.00000   80.0000000  -21.1632135 CY
  0.0010288         1328.      1290833.    3.4021269     0.0034999    -0.0035717
 3.9973919       0.00000   80.0000000  -22.5734966 CY
  0.0010888         1352.      1242162.    3.3994527     0.0037012    -0.0037829
 3.9996063       0.00000   80.0000000  -23.9744928 CY
  0.0011488         1372.      1194618.    3.3973521     0.0039027    -0.0039938
 3.9991134       0.00000   80.0000000  -25.3656831 CY


Axial Thrust Force =     80.000 kips

   Bending        Bending        Bending        Depth to       Max Comp       Max Tens
 Max Conc       Max Steel     Max Casing      Max Core    Run
  Curvature        Moment        Stiffness       N Axis         Strain         Strain
  Stress         Stress         Stress         Stress     Msg
   rad/in.        in-kip         kip-in2          in            in/in          in/in
    ksi            ksi            ksi            ksi
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   0.00000125    1.9758108     1580649.  159.4925295    0.0001994    0.0001908
   0.8006971      0.00000    5.7803583    5.6831771
   0.00000250    3.9516213     1580649.   81.4650955    0.0002037    0.0001865
   0.8168127      0.00000    5.9037276    5.7093653
   0.00000375    5.9274312     1580648.   55.4560978    0.0002080    0.0001822
   0.8328896      0.00000    6.0271129    5.7355694
   0.00000500    7.9032402     1580648.   42.4517091    0.0002123    0.0001779
   0.8489279      0.00000    6.1505142    5.7617895
   0.00000625    9.8790481     1580648.   34.6491642    0.0002166    0.0001736
   0.8649276      0.00000    6.2739315    5.7880256
   0.00000750   11.8548545     1580647.   29.4475410    0.0002209    0.0001693
   0.8808886      0.00000    6.3973647    5.8142777
   0.00000875   13.8306591     1580647.   25.7321589    0.0002252    0.0001650
   0.8968109      0.00000    6.5208139    5.8405457
   0.00001000   15.8064616     1580646.   22.9456774    0.0002295    0.0001607
   0.9126945      0.00000    6.6442792    5.8668298
   0.00001125   17.7822618     1580645.   20.7784630    0.0002338    0.0001564
   0.9285394      0.00000    6.7677604    5.8931298
   0.00001250   19.7580593     1580645.   19.0447356    0.0002381    0.0001521
   0.9443457      0.00000    6.8912576    5.9194458
   0.00001375   21.7338539     1580644.   17.6262714    0.0002424    0.0001478
   0.9601131      0.00000    7.0147707    5.9457778
   0.00001500   23.7096453     1580643.   16.4442547    0.0002467    0.0001436
   0.9758418      0.00000    7.1382999    5.9721258
   0.00001625   25.6854331     1580642.   15.4441207    0.0002510    0.0001393
   0.9915318      0.00000    7.2618450    5.9984898
   0.00001750   27.6612171     1580641.   14.5868944    0.0002553    0.0001350
   1.0071829      0.00000    7.3854062    6.0248697
   0.00001875   29.6369969     1580640.   13.8439943    0.0002596    0.0001307
   1.0227953      0.00000    7.5089833    6.0512657
   0.00002000   31.6127723     1580639.   13.1939844    0.0002639    0.0001264
   1.0383688      0.00000    7.6325764    6.0776776
   0.00002125   33.5885430     1580637.   12.6204721    0.0002682    0.0001221
   1.0539036      0.00000    7.7561855    6.1041055
   0.00002250   35.5643087     1580636.   12.1107079    0.0002725    0.0001178
   1.0693994      0.00000    7.8798105    6.1305494
   0.00002375   37.5400691     1580634.   11.6546263    0.0002768    0.0001135
   1.0848564      0.00000    8.0034516    6.1570093
   0.00002500   39.5158239     1580633.   11.2441749    0.0002811    0.0001093
   1.1002745      0.00000    8.1271086    6.1834851
   0.00002625   41.4915728     1580631.   10.8728351    0.0002854    0.0001050
   1.1156538      0.00000    8.2507816    6.2099770
   0.00002750   43.4673155     1580630.   10.5352735    0.0002897    0.0001007
   1.1309941      0.00000    8.3744706    6.2364848
   0.00002875   45.4430518     1580628.   10.2270843    0.0002940   0.00009640
   1.1462954      0.00000    8.4981756    6.2630086
   0.00003000   47.4187812     1580626.    9.9445959    0.0002983   0.00009212
   1.1615579      0.00000    8.6218966    6.2895484
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0.00003125	49.3945036	1580624.	9.6847242	0.0003026	0.00008784
1.1767814	0.00000	8.7456336	6.3161042		
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1.1919659	0.00000	8.8693865	6.3426760		
0.00003375	53.3459259	1580620.	9.2227790	0.0003113	0.00007927
1.2071114	0.00000	8.9931554	6.3692637		
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1.2222179	0.00000	9.1169404	6.3958675		
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1.2372854	0.00000	9.2407413	6.4224872		
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1.2523138	0.00000	9.3645581	6.4491229		
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1.2673032	0.00000	9.4883910	6.4757746		
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1.2822535	0.00000	9.6122399	6.5024423		
0.00004125	65.1999925	1580606.	8.1732244	0.0003371	0.00005359
1.2971648	0.00000	9.7361047	6.5291260		
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1.3120369	0.00000	9.8599856	6.5558256		
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1.3268699	0.00000	9.9838824	6.5825413		
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1.3416638	0.00000	10.1077952	6.6092729		
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1.3564185	0.00000	10.2317240	6.6360205		
0.00004750	75.0781165	1580592.	7.5520968	0.0003587	0.00003221
1.3711341	0.00000	10.3556688	6.6627841		
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1.3858104	0.00000	10.4796295	6.6895637		
0.00005125	81.0048588	1580583.	7.2522666	0.0003717	0.00001939
1.4150456	0.00000	10.7275990	6.7431708		
0.00005375	84.9559605	1580576.	7.0756738	0.0003803	0.00001084
1.4441238	0.00000	10.9756324	6.7968419		
0.00005625	88.9070114	1580569.	6.9148173	0.0003890	0.00000230
1.4730450	0.00000	11.2237298	6.8505770		
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1.5018091	0.00000	11.4718912	6.9043760		
0.00006125	96.8089517	1580554.	6.6326058	0.0004062	-0.00001479
1.5304158	0.00000	11.7201165	6.9582389		
0.00006375	100.7598363	1580546.	6.5081526	0.0004149	-0.00002332
1.5588651	0.00000	11.9684057	7.0121658		
0.00006625	104.7106598	1580538.	6.3931254	0.0004235	-0.00003186
1.5871568	0.00000	12.2167589	7.0661566		
0.00006875	108.6613891	1580529.	6.2864954	0.0004322	-0.00004039
1.6152908	0.00000	12.4651753	7.1202107		
0.00007125	112.6119227	1580518.	6.1873777	0.0004409	-0.00004892
1.6432666	0.00000	12.7136524	7.1743254		
0.00007375	116.5621326	1580503.	6.0950067	0.0004495	-0.00005745
1.6710838	0.00000	12.9621869	7.2284975		

0.00007625	120.5118898	1580484.	6.0087172	0.0004582	-0.00006598
1.6987418	0.00000	13.2107754	7.2827237		
0.00007875	124.4610677	1580458.	5.9279285	0.0004668	-0.00007450
1.7262401	0.00000	13.4594146	7.3370005		
0.00008125	128.4095505	1580425.	5.8521316	0.0004755	-0.00008303
1.7535784	0.00000	13.7081010	7.3913247		
0.00008375	132.3572324	1580385.	5.7808781	0.0004841	-0.00009155
1.7807561	0.00000	13.9568318	7.4456930		
0.00008625	136.3040174	1580336.	5.7137717	0.0004928	-0.0001001
1.8077730	0.00000	14.2056039	7.5001028		
0.00008875	140.2498187	1580280.	5.6504611	0.0005015	-0.0001086
1.8346285	0.00000	14.4544146	7.5545512		
0.00009125	143.3397998	1570847.	5.5817347	0.0005093	-0.0001179
1.8588034	0.00000	14.6797128	7.5854870 C		
0.00009375	147.1173383	1569252.	5.5235642	0.0005178	-0.0001266
1.8848356	0.00000	14.9237470	7.6351589 C		
0.00009625	150.8826129	1567612.	5.4682871	0.0005263	-0.0001353
1.9106705	0.00000	15.1674213	7.6844709 C		
0.00009875	154.6344094	1565918.	5.4156636	0.0005348	-0.0001440
1.9363030	0.00000	15.4106798	7.7333669 C		
0.0001013	158.3765473	1564213.	5.3655400	0.0005433	-0.0001527
1.9617471	0.00000	15.6536484	7.7819732 C		
0.0001038	162.1103365	1562509.	5.3177503	0.0005517	-0.0001615
1.9870077	0.00000	15.8963707	7.8303332 C		
0.0001063	165.8333022	1560784.	5.2720964	0.0005602	-0.0001702
2.0120750	0.00000	16.1387448	7.8783450 C		
0.0001088	169.5470990	1559054.	5.2284474	0.0005686	-0.0001790
2.0369548	0.00000	16.3808218	7.9260596 C		
0.0001113	173.2556227	1557354.	5.1867154	0.0005770	-0.0001877
2.0616632	0.00000	16.6227548	7.9736302 C		
0.0001138	176.9526622	1555628.	5.1466947	0.0005854	-0.0001965
2.0861740	0.00000	16.8642814	8.0207945 C		
0.0001163	180.6453009	1553938.	5.1083596	0.0005938	-0.0002053
2.1105168	0.00000	17.1056878	8.0678386 C		
0.0001188	184.3298844	1552252.	5.0715581	0.0006022	-0.0002140
2.1346761	0.00000	17.3468168	8.1146052 C		
0.0001213	188.0089330	1550589.	5.0362235	0.0006106	-0.0002228
2.1586622	0.00000	17.5877677	8.1611938 C		
0.0001238	191.6816268	1548942.	5.0022567	0.0006190	-0.0002316
2.1824720	0.00000	17.8285037	8.2075674 C		
0.0001263	195.3493263	1547321.	4.9695907	0.0006274	-0.0002404
2.2061109	0.00000	18.0690772	8.2537785 C		
0.0001288	199.0107133	1545714.	4.9381332	0.0006358	-0.0002492
2.2295732	0.00000	18.3094263	8.2997653 C		
0.0001313	202.6692203	1544146.	4.9078560	0.0006442	-0.0002581
2.2528745	0.00000	18.5497066	8.3456833 C		
0.0001338	206.3198957	1542579.	4.8786307	0.0006525	-0.0002669
2.2759915	0.00000	18.7896765	8.3912908 C		
0.0001363	209.9698850	1541063.	4.8504874	0.0006609	-0.0002757
2.2989583	0.00000	19.0296841	8.4369361 C		

0.0001388	213.6118200	1539545.	4.8232741	0.0006692	-0.0002845	2.3217389	0.00000	19.2693534	8.4822430	C
0.0001413	217.2516900	1538065.	4.7970162	0.0006776	-0.0002934	2.3443629	0.00000	19.5089898	8.5275170	C
0.0001438	220.8889966	1536619.	4.7716564	0.0006859	-0.0003022	2.3668275	0.00000	19.7485632	8.5727280	C
0.0001463	224.5193541	1535175.	4.7470934	0.0006943	-0.0003111	2.3891110	0.00000	19.9878384	8.6176410	C
0.0001488	228.1490065	1533775.	4.7233644	0.0007026	-0.0003199	2.4112447	0.00000	20.2271499	8.6625901	C
0.0001588	242.6338745	1528402.	4.6356730	0.0007359	-0.0003553	2.4981458	0.00000	21.1832490	8.8412398	C
0.0001688	257.0719134	1523389.	4.5580603	0.0007692	-0.0003908	2.5824689	0.00000	22.1378101	9.0183514	C
0.0001788	271.4730291	1518730.	4.4889275	0.0008024	-0.0004263	2.6642666	0.00000	23.0913132	9.1944052	C
0.0001888	285.8420042	1514395.	4.4269682	0.0008356	-0.0004619	2.7435655	0.00000	24.0439848	9.3696274	C
0.0001988	300.1810829	1510345.	4.3711131	0.0008688	-0.0004974	2.8203781	0.00000	24.9959035	9.5440967	C
0.0002088	314.4922148	1506550.	4.3204945	0.0009019	-0.0005330	2.8947146	0.00000	25.9471267	9.7178705	C
0.0002188	328.7815846	1503002.	4.2744610	0.0009350	-0.0005686	2.9666118	0.00000	26.8980782	9.8913726	C
0.0002288	343.0507742	1499676.	4.2324288	0.0009682	-0.0006043	3.0360802	0.00000	27.8488735	10.0647184	C
0.0002388	357.2957037	1496527.	4.1938356	0.0010013	-0.0006399	3.1030922	0.00000	28.7991006	10.2374962	C
0.0002488	371.5268838	1493575.	4.1583944	0.0010344	-0.0006755	3.1677142	0.00000	29.7496868	10.4106329	C
0.0002588	385.7342866	1490761.	4.1256109	0.0010675	-0.0007111	3.2298800	0.00000	30.6996433	10.5831401	C
0.0002688	399.9297782	1488111.	4.0953335	0.0011006	-0.0007468	3.2896657	0.00000	31.6501296	10.7561770	C
0.0002788	414.1056902	1485581.	4.0671938	0.0011337	-0.0007824	3.3470196	0.00000	32.6003355	10.9289335	C
0.0002888	428.2679164	1483179.	4.0410434	0.0011669	-0.0008180	3.4019786	0.00000	33.5508789	11.1020274	C
0.0002988	442.4167048	1480893.	4.0166844	0.0012000	-0.0008536	3.4545411	0.00000	34.5017770	11.2754762	C
0.0003088	456.5474911	1478696.	3.9938838	0.0012331	-0.0008892	3.5046770	0.00000	35.4524950	11.4487448	C
0.0003188	470.6662358	1476600.	3.9725700	0.0012663	-0.0009248	3.5524219	0.00000	36.4037345	11.6225349	C
0.0003288	484.7729003	1474594.	3.9526073	0.0012994	-0.0009604	3.5977717	0.00000	37.3554938	11.7968448	C
0.0003388	498.8616671	1472654.	3.9337996	0.0013326	-0.0009960	3.6406895	0.00000	38.3070210	11.9709226	C
0.0003488	512.9382982	1470791.	3.9161218	0.0013657	-0.0010316	3.6812081	0.00000	39.2590670	12.1455192	C

0.0003588	527.0027769	1468997.	3.8994798	0.0013989	-0.0010671
3.7193236	0.00000	40.2116355	12.3206383 C		
0.0003688	541.0550643	1467268.	3.8837893	0.0014321	-0.0011026
3.7550323	0.00000	41.1647282	12.4962815 C		
0.0003788	555.0906949	1465586.	3.8689152	0.0014654	-0.0011382
3.7883077	0.00000	42.1176862	12.6717902 C		
0.0003888	569.1141015	1463959.	3.8548531	0.0014986	-0.0011737
3.8191717	0.00000	43.0711712	12.8478258 C		
0.0003988	583.1252484	1462383.	3.8415418	0.0015318	-0.0012092
3.8476201	0.00000	44.0251839	13.0243891 C		
0.0004088	597.1241010	1460854.	3.8289266	0.0015651	-0.0012447
3.8736490	0.00000	44.9797260	13.2014818 C		
0.0004188	611.1106247	1459369.	3.8169576	0.0015984	-0.0012801
3.8972543	0.00000	45.9347990	13.3791054 C		
0.0004288	625.0820492	1457917.	3.8055516	0.0016316	-0.0013156
3.9184222	0.00000	46.8899306	13.5567875 C		
0.0004388	639.0405703	1456503.	3.7947003	0.0016649	-0.0013510
3.9371591	0.00000	47.8455039	13.7349115 C		
0.0004488	652.9866863	1455124.	3.7843738	0.0016982	-0.0013865
3.9534633	0.00000	48.8016126	13.9135708 C		
0.0004588	666.9203619	1453777.	3.7745378	0.0017316	-0.0014219
3.9673305	0.00000	49.7582585	14.0927672 C		
0.0004688	680.8415617	1452462.	3.7651611	0.0017649	-0.0014573
3.9787568	0.00000	50.7154430	14.2725024 C		
0.0004788	694.7502500	1451175.	3.7562151	0.0017983	-0.0014926
3.9877379	0.00000	51.6731681	14.4527781 C		
0.0004888	708.6463912	1449916.	3.7476734	0.0018317	-0.0015280
3.9942698	0.00000	52.6314353	14.6335959 C		
0.0004988	722.5280622	1448678.	3.7394844	0.0018651	-0.0015633
3.9983470	0.00000	53.5898504	14.8145616 C		
0.0005088	736.3967747	1447463.	3.7316492	0.0018985	-0.0015987
3.9999687	0.00000	54.5487351	14.9959968 C		
0.0005188	750.2528582	1446271.	3.7241525	0.0019319	-0.0016340
3.9999306	0.00000	55.5081672	15.1779796 C		
0.0005288	764.0962761	1445099.	3.7169752	0.0019654	-0.0016693
3.9998438	0.00000	56.4681487	15.3605117 C		
0.0005388	777.9269919	1443948.	3.7100996	0.0019988	-0.0017046
3.9996723	0.00000	57.4286813	15.5435948 C		
0.0005488	791.7449688	1442815.	3.7035093	0.0020323	-0.0017398
3.9993677	0.00000	58.3897667	15.7272309 C		
0.0006088	874.3770605	1436348.	3.6691506	0.0022336	-0.0019510
3.9999214	0.00000	64.1675101	16.8402779 C		
0.0006688	956.5114569	1430298.	3.6419644	0.0024356	-0.0021614
3.9992787	0.00000	69.9647867	17.9728581 C		
0.0007288	1038.	1424647.	3.6201837	0.0026382	-0.0023712
3.9993239	0.00000	75.7816923	19.1250673 C		
0.0007888	1119.	1418952.	3.6028493	0.0028417	-0.0025801
3.9979151	0.00000	80.0000000	20.3031843 CY		
0.0008488	1193.	1405283.	3.5965358	0.0030526	-0.0027817
3.9990054	0.00000	80.0000000	21.6922440 CY		

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  0.0009088        1251.      1376779.     3.6009962     0.0032724    -0.0029743
 3.9995776       0.00000    80.0000000    23.3432631 CY
  0.0009688        1294.      1335919.     3.6053634     0.0034927    -0.0031665
 3.9992931       0.00000    80.0000000    25.0071777 CY
  0.0010288        1326.      1289046.     3.6061649     0.0037098    -0.0033618
 3.9971432       0.00000    80.0000000    26.5799313 CY
  0.0010888        1351.      1240704.     3.6053292     0.0039253    -0.0035588
 3.9995904       0.00000    80.0000000    28.1037711 CY
```

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	-7.000	1255.559	0.00300000
2	32.500	1225.409	0.00300000
3	80.000	1174.400	0.00300000

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	-7.000000	1256.	-4.550000	816.113136	1424942.
2	0.65	32.500000	1225.	21.125000	796.515998	1433844.

```
   3       0.65           80.000000          1174.     52.000000    763.360031
1445162.

   1       0.75           -7.000000          1256.     -5.250000    941.669003
1419997.
   2       0.75           32.500000          1225.     24.375000    919.056920
1426908.
   3       0.75           80.000000          1174.     60.000000    880.800036
1435875.

   1       0.90           -7.000000          1256.     -6.300000         1130.
1409285.
   2       0.90           32.500000          1225.     29.250000         1103.
1416926.
   3       0.90           80.000000          1174.     72.000000         1057.
1423329.
```

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	144160.
2	11.0000	11.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                               =       2000.0 lbs
Applied moment at pile head                            =          0.0 in-lbs
```

Axial thrust load on pile head = 80000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.06605	-4.74E-08	2000.	-0.00164	0.00	1.58E+09	0.00	0.00	0.00
0.1500	0.06310	3836.	1992.	-0.00164	0.00	1.58E+09	-8.7666	250.0815	0.00
0.3000	0.06015	7644.	1968.	-0.00163	0.00	1.58E+09	-18.1596	543.4026	0.00
0.4500	0.05722	11391.	1927.	-0.00162	0.00	1.58E+09	-27.4485	863.4148	0.00
0.6000	0.05432	15047.	1870.	-0.00161	0.00	1.58E+09	-36.1611	1198.	0.00
0.7500	0.05144	18584.	1797.	-0.00159	0.00	1.58E+09	-43.9959	1539.	0.00
0.9000	0.04860	21975.	1712.	-0.00156	0.00	1.58E+09	-50.7517	1880.	0.00
1.0500	0.04581	25198.	1616.	-0.00154	0.00	1.58E+09	-56.2755	2211.	0.00
1.2000	0.04307	28235.	1511.	-0.00151	0.00	1.58E+09	-60.4144	2525.	0.00
1.3500	0.04039	31071.	1400.	-0.00147	0.00	1.58E+09	-62.9557	2806.	0.00
1.5000	0.03777	33698.	1286.	-0.00144	0.00	1.58E+09	-63.5199	3027.	0.00
1.6500	0.03522	36114.	1167.	-0.00140	0.00	1.58E+09	-68.6712	3510.	0.00
1.8000	0.03274	38301.	1040.	-0.00135	0.00	1.58E+09	-72.8426	4005.	0.00
1.9500	0.03034	40247.	905.8187	-0.00131	0.00	1.58E+09	-75.8315	4499.	0.00
2.1000	0.02803	41939.	767.6806	-0.00126	0.00	1.58E+09	-77.6552	4987.	0.00
2.2500	0.02580	43374.	627.2538	-0.00121	0.00	1.58E+09	-78.3746	5469.	0.00
2.4000	0.02366	44547.	486.4460	-0.00116	0.00	1.58E+09	-78.0785	5941.	0.00
2.5500	0.02161	45460.	346.9910	-0.00111	0.00	1.58E+09	-76.8715	6404.	0.00
2.7000	0.01965	46117.	210.4286	-0.00106	0.00	1.58E+09	-74.8646	6857.	0.00
2.8500	0.01779	46523.	78.0980	-0.00101	0.00	1.58E+09	-72.1693	7302.	0.00

3.0000	0.01602	46688.	-48.8580	-9.55E-04	0.00	1.58E+09	-68.8930	7739.	0.00
3.1500	0.01435	46622.	-169.4851	-9.01E-04	0.00	1.58E+09	-65.1371	8169.	0.00
3.3000	0.01278	46338.	-283.0047	-8.49E-04	0.00	1.58E+09	-60.9958	8592.	0.00
3.4500	0.01130	45848.	-388.8009	-7.96E-04	0.00	1.58E+09	-56.5555	9010.	0.00
3.6000	0.00991	45167.	-486.4062	-7.44E-04	0.00	1.58E+09	-51.8949	9423.	0.00
3.7500	0.00862	44311.	-575.4882	-6.93E-04	0.00	1.58E+09	-47.0852	9833.	0.00
3.9000	0.00742	43295.	-655.8365	-6.43E-04	0.00	1.58E+09	-42.1907	10239.	0.00
4.0500	0.00630	42135.	-727.3502	-5.95E-04	0.00	1.58E+09	-37.2690	10643.	0.00
4.2000	0.00528	40848.	-790.0268	-5.47E-04	0.00	1.58E+09	-32.3717	11044.	0.00
4.3500	0.00433	39449.	-843.9511	-5.02E-04	0.00	1.58E+09	-27.5443	11444.	0.00
4.5000	0.00347	37954.	-889.2855	-4.58E-04	0.00	1.58E+09	-22.8272	11842.	0.00
4.6500	0.00268	36379.	-926.2601	-4.15E-04	0.00	1.58E+09	-18.2557	12240.	0.00
4.8000	0.00197	34739.	-955.1645	-3.75E-04	0.00	1.58E+09	-13.8603	12636.	0.00
4.9500	0.00134	33049.	-976.3391	-3.36E-04	0.00	1.58E+09	-9.6670	13032.	0.00
5.1000	7.64E-04	31321.	-990.1674	-3.00E-04	0.00	1.58E+09	-5.6977	13427.	0.00
5.2500	2.57E-04	29570.	-997.0686	-2.65E-04	0.00	1.58E+09	-1.9703	13823.	0.00
5.4000	-1.90E-04	27808.	-997.4910	-2.32E-04	0.00	1.58E+09	1.5010	14218.	0.00
5.5500	-5.80E-04	26046.	-991.9051	-2.02E-04	0.00	1.58E+09	4.7055	14612.	0.00
5.7000	-9.16E-04	24295.	-980.7980	-1.73E-04	0.00	1.58E+09	7.6358	15007.	0.00
5.8500	-0.00120	22565.	-964.6672	-1.46E-04	0.00	1.58E+09	10.2873	15402.	0.00
6.0000	-0.00144	20865.	-944.0159	-1.22E-04	0.00	1.58E+09	12.6586	15797.	0.00
6.1500	-0.00164	19202.	-919.3477	-9.87E-05	0.00	1.58E+09	14.7505	16191.	0.00
6.3000	-0.00180	17583.	-891.1625	-7.78E-05	0.00	1.58E+09	16.5663	16586.	0.00
6.4500	-0.00192	16016.	-859.9525	-5.87E-05	0.00	1.58E+09	18.1115	16981.	0.00
6.6000	-0.00201	14504.	-826.1981	-4.13E-05	0.00	1.58E+09	19.3933	17376.	0.00

6.7500	-0.00207	13053.	-790.3654	-2.56E-05	0.00	1.58E+09	20.4208	17771.	0.00
6.9000	-0.00210	11667.	-752.9027	-1.15E-05	0.00	1.58E+09	21.2044	18165.	0.00
7.0500	-0.00211	10346.	-714.2386	1.02E-06	0.00	1.58E+09	21.7557	18560.	0.00
7.2000	-0.00210	9095.	-674.7796	1.21E-05	0.00	1.58E+09	22.0876	18955.	0.00
7.3500	-0.00207	7914.	-634.9084	2.18E-05	0.00	1.58E+09	22.2137	19350.	0.00
7.5000	-0.00202	6803.	-594.9827	3.02E-05	0.00	1.58E+09	22.1482	19745.	0.00
7.6500	-0.00196	5763.	-555.3341	3.73E-05	0.00	1.58E+09	21.9059	20140.	0.00
7.8000	-0.00188	4793.	-516.2670	4.33E-05	0.00	1.58E+09	21.5019	20535.	0.00
7.9500	-0.00180	3892.	-478.0588	4.83E-05	0.00	1.58E+09	20.9517	20931.	0.00
8.1000	-0.00171	3058.	-440.9588	5.22E-05	0.00	1.58E+09	20.2705	21326.	0.00
8.2500	-0.00161	2289.	-405.1888	5.53E-05	0.00	1.58E+09	19.4739	21721.	0.00
8.4000	-0.00151	1584.	-370.9432	5.75E-05	0.00	1.58E+09	18.5769	22116.	0.00
8.5500	-0.00141	937.5493	-338.3889	5.89E-05	0.00	1.58E+09	17.5946	22511.	0.00
8.7000	-0.00130	348.3925	-307.6662	5.96E-05	0.00	1.58E+09	16.5417	22906.	0.00
8.8500	-0.00119	-187.2262	-278.8893	5.97E-05	0.00	1.58E+09	15.4326	23301.	0.00
9.0000	-0.00108	-672.8125	-252.1467	5.92E-05	0.00	1.58E+09	14.2813	23696.	0.00
9.1500	-9.79E-04	-1112.	-227.5023	5.82E-05	0.00	1.58E+09	13.1014	24091.	0.00
9.3000	-8.75E-04	-1509.	-204.9958	5.67E-05	0.00	1.58E+09	11.9059	24486.	0.00
9.4500	-7.75E-04	-1866.	-184.6436	5.48E-05	0.00	1.58E+09	10.7077	24881.	0.00
9.6000	-6.78E-04	-2189.	-166.4395	5.25E-05	0.00	1.58E+09	9.5190	25276.	0.00
9.7500	-5.86E-04	-2481.	-150.3557	4.98E-05	0.00	1.58E+09	8.3519	25671.	0.00
9.9000	-4.98E-04	-2745.	-136.3428	4.69E-05	0.00	1.58E+09	7.2179	26066.	0.00
10.0500	-4.17E-04	-2985.	-124.3312	4.36E-05	0.00	1.58E+09	6.1284	26461.	0.00
10.2000	-3.41E-04	-3205.	-114.2307	4.01E-05	0.00	1.58E+09	5.0944	26855.	0.00
10.3500	-2.73E-04	-3408.	-105.9317	3.63E-05	0.00	1.58E+09	4.1267	27250.	0.00

10.5000	-2.11E-04	-3597.	-99.3053	3.23E-05	0.00	1.58E+09	3.2360	27645.	0.00
10.6500	-1.56E-04	-3775.	-94.2031	2.81E-05	0.00	1.58E+09	2.4331	28040.	0.00
10.8000	-1.09E-04	-3944.	-90.4576	2.37E-05	0.00	1.58E+09	1.7285	28435.	0.00
10.9500	-7.07E-05	-4107.	-87.8825	1.92E-05	0.00	1.58E+09	1.1328	28830.	0.00
11.1000	-4.05E-05	-4266.	32.0312	1.44E-05	0.00	1.58E+09	132.1046	5877788.	0.00
11.2500	-1.89E-05	-3996.	278.5513	9.68E-06	0.00	1.58E+09	141.8066	1.35E+07	0.00
11.4000	-5.59E-06	-3266.	509.6910	5.55E-06	0.00	1.58E+09	115.0153	3.70E+07	0.00
11.5500	1.05E-06	-2163.	590.2745	2.46E-06	0.00	1.58E+09	-25.4781	4.37E+07	0.00
11.7000	3.26E-06	-1142.	485.2334	5.77E-07	0.00	1.58E+09	-91.2341	5.04E+07	0.00
11.8500	3.13E-06	-415.9173	313.8493	-3.10E-07	0.00	1.58E+09	-99.1927	5.71E+07	0.00
12.0000	2.14E-06	-11.6020	156.2087	-5.53E-07	0.00	1.58E+09	-75.9635	6.38E+07	0.00
12.1500	1.14E-06	146.5934	47.8018	-4.76E-07	0.00	1.58E+09	-44.4886	7.05E+07	0.00
12.3000	4.29E-07	160.6216	-8.8033	-3.01E-07	0.00	1.58E+09	-18.4059	7.72E+07	0.00
12.4500	5.17E-08	114.9882	-27.5351	-1.44E-07	0.00	1.58E+09	-2.4072	8.39E+07	0.00
12.6000	-9.03E-08	61.5367	-25.6146	-4.38E-08	0.00	1.58E+09	4.5411	9.06E+07	0.00
12.7500	-1.06E-07	22.7884	-16.4455	4.21E-09	0.00	1.58E+09	5.6467	9.58E+07	0.00
12.9000	-7.51E-08	2.3316	-7.7637	1.85E-08	0.00	1.58E+09	3.9998	9.58E+07	0.00
13.0500	-3.94E-08	-5.1664	-2.2754	1.69E-08	0.00	1.58E+09	2.0984	9.58E+07	0.00
13.2000	-1.43E-08	-5.8648	0.2979	1.06E-08	0.00	1.58E+09	0.7609	9.58E+07	0.00
13.3500	-1.19E-09	-4.0970	1.0398	4.94E-09	0.00	1.58E+09	0.06349	9.58E+07	0.00
13.5000	3.51E-09	-2.1229	0.9289	1.40E-09	0.00	1.58E+09	-0.1867	9.58E+07	0.00
13.6500	3.85E-09	-0.7533	0.5763	-2.37E-10	0.00	1.58E+09	-0.2051	9.58E+07	0.00
13.8000	2.65E-09	-0.04805	0.2646	-6.93E-10	0.00	1.58E+09	-0.1413	9.58E+07	0.00
13.9500	1.36E-09	0.1993	0.07231	-6.07E-10	0.00	1.58E+09	-0.07229	9.58E+07	0.00
14.1000	4.70E-10	0.2124	-0.01527	-3.72E-10	0.00	1.58E+09	-0.02502	9.58E+07	0.00

```
   14.2500   1.74E-11     0.1444   -0.03862  -1.69E-10       0.00   1.58E+09
-9.29E-04   9.58E+07       0.00
   14.4000  -1.39E-10    0.07343   -0.03280  -4.50E-11       0.00   1.58E+09
0.00739   9.58E+07       0.00
   14.5500  -1.45E-10    0.02636   -0.01922   1.18E-11       0.00   1.58E+09
0.00770   9.58E+07       0.00
   14.7000  -9.63E-11    0.00423   -0.00768   2.92E-11       0.00   1.58E+09
0.00513   9.58E+07       0.00
   14.8500  -3.94E-11   -0.00128   -0.00117   3.09E-11       0.00   1.58E+09
0.00210   9.58E+07       0.00
   15.0000   1.49E-11       0.00       0.00   3.02E-11       0.00   1.58E+09
-7.95E-04   4.79E+07       0.00
```

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.06605232 inches
Computed slope at pile head      =    -0.00164086 radians
Maximum bending moment           =         46688. inch-lbs
Maximum shear force              =          2000. lbs
Depth of maximum bending moment  =     3.00000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              6
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                             =       8000.0 lbs
Applied moment at pile head                          =          0.0 in-lbs
Axial thrust load on pile head                       =      32500.0 lbs
```

```
   Depth    Deflect.    Bending     Shear      Slope      Total     Bending   Soil
Res.  Soil Spr.  Distrib.
     X          y       Moment      Force        S       Stress    Stiffness      p
      Es*H     Lat. Load
   feet      inches     in-lbs       lbs      radians     psi*      lb-in^2
```

```
lb/inch    lb/inch    lb/inch
---------- ---------- ---------- ---------- ---------- ---------- ----------
---------- ---------- ----------
      0.00     0.5417  -1.53E-06      8000.   -0.01130       0.00   1.60E+09
0.00       0.00       0.00
    0.1500     0.5214     15061.      7991.   -0.01129       0.00   1.60E+09
-9.9077    34.2049       0.00
    0.3000     0.5011     30089.      7963.   -0.01126       0.00   1.60E+09
-21.6192    77.6610      0.00
    0.4500     0.4808     45044.      7912.   -0.01122       0.00   1.60E+09
-34.3330   128.5236      0.00
    0.6000     0.4607     59886.      7839.   -0.01116       0.00   1.60E+09
-47.2478   184.6051      0.00
    0.7500     0.4407     74570.      7743.   -0.01108       0.00   1.60E+09
-59.5622   243.2963      0.00
    0.9000     0.4208     89057.      7626.   -0.01099       0.00   1.60E+09
-70.4746   301.4693      0.00
    1.0500     0.4011    103309.      7491.   -0.01088       0.00   1.54E+09
-79.1839   355.3583      0.00
    1.2000     0.3816    117298.      7343.   -0.01075       0.00   1.53E+09
-84.8885   400.4047      0.00
    1.3500     0.3624    131003.      7189.   -0.01061       0.00   1.52E+09
-86.7871   431.0837      0.00
    1.5000     0.3434    144419.      7035.   -0.01044       0.00   1.52E+09
-84.0782   440.6748      0.00
    1.6500     0.3248    157552.      6871.   -0.01026       0.00   1.51E+09
-98.2720   544.6337      0.00
    1.8000     0.3065    170355.      6680.   -0.01007       0.00   1.50E+09
-114.0917   670.0739      0.00
    1.9500     0.2885    182777.      6459.   -0.00986       0.00   1.50E+09
-131.0586   817.5740      0.00
    2.1000     0.2710    194762.      6207.   -0.00963       0.00   1.50E+09
-149.1705   990.8012      0.00
    2.2500     0.2539    206249.      5921.   -0.00939       0.00   1.49E+09
-168.4211      1194.      0.00
    2.4000     0.2372    217176.      5600.   -0.00913       0.00   1.49E+09
-188.7925      1433.      0.00
    2.5500     0.2210    227476.      5241.   -0.00886       0.00   1.49E+09
-210.2403      1712.      0.00
    2.7000     0.2053    237079.      4842.   -0.00858       0.00   1.49E+09
-232.6689      2040.      0.00
    2.8500     0.1901    245912.      4402.   -0.00829       0.00   1.48E+09
-255.8919      2423.      0.00
    3.0000     0.1755    253897.      3920.   -0.00799       0.00   1.48E+09
-279.5816      2868.      0.00
    3.1500     0.1614    260959.      3396.   -0.00767       0.00   1.48E+09
-303.2139      3383.      0.00
    3.3000     0.1478    267020.      2830.   -0.00735       0.00   1.48E+09
-326.0240      3970.      0.00
    3.4500     0.1349    272006.      2224.   -0.00702       0.00   1.48E+09
```

```
-346.9972      4631.       0.00
    3.6000     0.1225    275848.       1583.   -0.00669       0.00   1.48E+09
-364.9149      5360.       0.00
    3.7500     0.1108    278488.   914.0180   -0.00635       0.00   1.48E+09
-378.4709      6149.       0.00
    3.9000    0.09966    279882.   225.5915   -0.00601       0.00   1.48E+09
-386.4474      6979.       0.00
    4.0500    0.08915    280003.  -471.3331   -0.00567       0.00   1.48E+09
-387.9133      7833.       0.00
    4.2000    0.07924    278849.      -1165.   -0.00533       0.00   1.48E+09
-382.3887      8686.       0.00
    4.3500    0.06995    276435.      -1842.   -0.00499       0.00   1.48E+09
-369.9266      9519.       0.00
    4.5000    0.06126    272803.      -2491.   -0.00466       0.00   1.48E+09
-351.0874     10316.       0.00
    4.6500    0.05317    268014.      -3101.   -0.00433       0.00   1.48E+09
-326.8240     11064.       0.00
    4.8000    0.04567    262147.      -3663.   -0.00401       0.00   1.48E+09
-298.3190     11758.       0.00
    4.9500    0.03874    255295.      -4172.   -0.00369       0.00   1.48E+09
-266.8220     12397.       0.00
    5.1000    0.03237    247560.      -4622.   -0.00339       0.00   1.48E+09
-233.5205     12985.       0.00
    5.2500    0.02654    239051.      -5012.   -0.00309       0.00   1.49E+09
-199.4585     13527.       0.00
    5.4000    0.02123    229879.      -5340.   -0.00281       0.00   1.49E+09
-165.4997     14031.       0.00
    5.5500    0.01642    220154.      -5608.   -0.00254       0.00   1.49E+09
-132.3238     14502.       0.00
    5.7000    0.01209    209985.      -5818.   -0.00228       0.00   1.49E+09
-100.4424     14949.       0.00
    5.8500    0.00822    199476.      -5972.   -0.00203       0.00   1.50E+09
-70.2255     15376.       0.00
    6.0000    0.00478    188726.      -6072.   -0.00180       0.00   1.50E+09
-41.9280     15789.       0.00
    6.1500    0.00175    177826.      -6124.   -0.00158       0.00   1.50E+09
-15.7159     16191.       0.00
    6.3000  -9.02E-04    166862.      -6131.   -0.00137       0.00   1.51E+09
8.3129     16587.       0.00
    6.4500   -0.00319    155915.      -6096.   -0.00118       0.00   1.51E+09
30.1120     16978.       0.00
    6.6000   -0.00515    145053.      -6025.   -0.00100       0.00   1.52E+09
49.6729     17368.       0.00
    6.7500   -0.00679    134343.      -5920.  -8.35E-04       0.00   1.52E+09
67.0161     17756.       0.00
    6.9000   -0.00815    123840.      -5785.  -6.82E-04       0.00   1.53E+09
82.1841     18144.       0.00
    7.0500   -0.00925    113595.      -5626.  -5.43E-04       0.00   1.53E+09
95.2363     18533.       0.00
    7.2000   -0.01011    103651.      -5444.  -4.15E-04       0.00   1.54E+09
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106.2455     18923.        0.00
    7.3500   -0.01075     94044.      -5245.  -3.00E-04       0.00   1.55E+09
115.2954     19314.        0.00
    7.5000   -0.01119     84805.      -5031.  -1.98E-04       0.00   1.60E+09
122.4780     19706.        0.00
    7.6500   -0.01146     75956.      -4806.  -1.07E-04       0.00   1.60E+09
127.9392     20100.        0.00
    7.8000   -0.01157     67517.      -4572.  -2.63E-05       0.00   1.60E+09
131.7707     20495.        0.00
    7.9500   -0.01155     59500.      -4333.   4.53E-05       0.00   1.60E+09
134.0696     20891.        0.00
    8.1000   -0.01141     51914.      -4090.   1.08E-04       0.00   1.60E+09
134.9368     21287.        0.00
    8.2500   -0.01116     44762.      -3848.   1.63E-04       0.00   1.60E+09
134.4769     21684.        0.00
    8.4000   -0.01082     38043.      -3607.   2.09E-04       0.00   1.60E+09
132.7969     22082.        0.00
    8.5500   -0.01041     31751.      -3371.   2.49E-04       0.00   1.60E+09
130.0056     22480.        0.00
    8.7000   -0.00993     25878.      -3140.   2.81E-04       0.00   1.60E+09
126.2131     22878.        0.00
    8.8500   -0.00940     20413.      -2917.   3.07E-04       0.00   1.60E+09
121.5300     23276.        0.00
    9.0000   -0.00882     15340.      -2704.   3.27E-04       0.00   1.60E+09
116.0667     23674.        0.00
    9.1500   -0.00822     10642.      -2500.   3.42E-04       0.00   1.60E+09
109.9329     24073.        0.00
    9.3000   -0.00759      6299.      -2308.   3.51E-04       0.00   1.60E+09
103.2372     24470.        0.00
    9.4500   -0.00696      2291.      -2129.   3.56E-04       0.00   1.60E+09
96.0860     24868.        0.00
    9.6000   -0.00631     -1407.      -1963.   3.57E-04       0.00   1.60E+09
88.5872     25265.        0.00
    9.7500   -0.00567     -4817.      -1810.   3.53E-04       0.00   1.60E+09
80.8445     25662.        0.00
    9.9000   -0.00504     -7965.      -1672.   3.46E-04       0.00   1.60E+09
72.9602     26058.        0.00
   10.0500   -0.00442    -10876.      -1548.   3.35E-04       0.00   1.60E+09
65.0346     26455.        0.00
   10.2000   -0.00383    -13575.      -1438.   3.22E-04       0.00   1.60E+09
57.1668     26851.        0.00
   10.3500   -0.00327    -16089.      -1342.   3.05E-04       0.00   1.60E+09
49.4544     27247.        0.00
   10.5000   -0.00273    -18441.      -1259.   2.85E-04       0.00   1.60E+09
41.9941     27643.        0.00
   10.6500   -0.00224    -20656.      -1190.   2.63E-04       0.00   1.60E+09
34.8821     28039.        0.00
   10.8000   -0.00179    -22756.      -1133.   2.39E-04       0.00   1.60E+09
28.2141     28434.        0.00
   10.9500   -0.00138    -24764.      -1088.   2.12E-04       0.00   1.60E+09
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22.0861     28830.        0.00
   11.1000   -0.00102    -26698.  -802.8988   1.83E-04       0.00   1.60E+09
294.7936    519156.        0.00
   11.2500  -7.19E-04    -27676.  -222.9793   1.53E-04       0.00   1.60E+09
349.5614    874647.        0.00
   11.4000  -4.73E-04    -27519.   439.3583   1.21E-04       0.00   1.60E+09
386.3692   1470893.        0.00
   11.5500  -2.82E-04    -26108.      1149.   9.13E-05       0.00   1.60E+09
402.5123   2568600.        0.00
   11.7000  -1.44E-04    -23392.      1866.   6.34E-05       0.00   1.60E+09
393.6437   4911013.        0.00
   11.8500  -5.39E-05    -19398.      2535.   3.93E-05       0.00   1.60E+09
349.4512   1.17E+07        0.00
   12.0000  -2.95E-06    -14271.      2943.   2.03E-05       0.00   1.60E+09
104.4972   6.38E+07        0.00
   12.1500   1.91E-05     -8805.      2737.   7.28E-06       0.00   1.60E+09
-333.7058   3.15E+07        0.00
   12.3000   2.33E-05     -4419.      2091.  -1.67E-07       0.00   1.60E+09
-384.4002   2.97E+07        0.00
   12.4500   1.85E-05     -1279.      1389.  -3.38E-06       0.00   1.60E+09
-394.7790   3.84E+07        0.00
   12.6000   1.11E-05   582.9428   695.9915  -3.77E-06       0.00   1.60E+09
-375.6600   6.08E+07        0.00
   12.7500   4.92E-06      1227.   122.1200  -2.75E-06       0.00   1.60E+09
-261.9750   9.58E+07        0.00
   12.9000   1.21E-06      1023.  -171.8840  -1.48E-06       0.00   1.60E+09
-64.6960   9.58E+07       0.00
   13.0500  -4.15E-07   608.7505  -210.2262  -5.62E-07       0.00   1.60E+09
22.0936   9.58E+07       0.00
   13.2000  -8.10E-07   266.1477  -151.5265  -6.95E-08       0.00   1.60E+09
43.1284   9.58E+07       0.00
   13.3500  -6.65E-07    63.2633   -80.8376   1.16E-07       0.00   1.60E+09
35.4149   9.58E+07       0.00
   13.5000  -3.92E-07   -24.8811   -30.1831   1.38E-07       0.00   1.60E+09
20.8679   9.58E+07       0.00
   13.6500  -1.69E-07   -45.4120    -3.2944   9.81E-08       0.00   1.60E+09
9.0085   9.58E+07       0.00
   13.8000  -3.86E-08   -36.7524     6.6621   5.18E-08       0.00   1.60E+09
2.0543   9.58E+07       0.00
   13.9500   1.75E-08   -21.4344     7.6740   1.91E-08       0.00   1.60E+09
-0.9300   9.58E+07       0.00
   14.1000   3.00E-08    -9.1283     5.3978   1.84E-09       0.00   1.60E+09
-1.5991   9.58E+07       0.00
   14.2500   2.41E-08    -2.0026     2.8047  -4.44E-09       0.00   1.60E+09
-1.2821   9.58E+07       0.00
   14.4000   1.41E-08     0.9691     0.9768  -5.02E-09       0.00   1.60E+09
-0.7489   9.58E+07       0.00
   14.5500   6.01E-09     1.5144    0.01453  -3.62E-09       0.00   1.60E+09
-0.3203   9.58E+07       0.00
   14.7000   1.04E-09     1.0219    -0.3235  -2.19E-09       0.00   1.60E+09
```

							-0.05530	9.58E+07	0.00
14.8500	-1.87E-09	0.3500	-0.2839	-1.42E-09	0.00	1.60E+09	0.09932	9.58E+07	0.00
15.0000	-4.06E-09	0.00	0.00	-1.22E-09	0.00	1.60E+09	0.2161	4.79E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

```
Pile-head deflection             =     0.54171714 inches
Computed slope at pile head      =    -0.01129587 radians
Maximum bending moment           =        280003. inch-lbs
Maximum shear force              =          8000. lbs
Depth of maximum bending moment  =     4.05000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             18
Number of zero deflection points =              5
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                                =       8000.0 lbs
Applied moment at pile head                             =          0.0 in-lbs
Axial thrust load on pile head                          =      80000.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5809	-5.42E-08	8000.	-0.01203	0.00	1.58E+09	0.00	0.00	0.00
0.1500	0.5593	16133.	7991.	-0.01202	0.00	1.58E+09	-9.9077	31.8880	0.00

0.3000	0.5376	32230.	7963.	-0.01199	0.00	1.58E+09
-21.6192	72.3799	0.00				
0.4500	0.5161	48253.	7912.	-0.01195	0.00	1.58E+09
-34.3330	119.7466	0.00				
0.6000	0.4946	64156.	7839.	-0.01188	0.00	1.58E+09
-47.2478	171.9399	0.00				
0.7500	0.4733	79896.	7743.	-0.01180	0.00	1.58E+09
-59.5622	226.5201	0.00				
0.9000	0.4521	95429.	7626.	-0.01170	0.00	1.58E+09
-70.4747	280.5667	0.00				
1.0500	0.4312	110719.	7491.	-0.01159	0.00	1.58E+09
-79.1839	330.5693	0.00				
1.2000	0.4104	125734.	7343.	-0.01145	0.00	1.58E+09
-84.8885	372.2930	0.00				
1.3500	0.3899	140453.	7189.	-0.01130	0.00	1.58E+09
-86.7871	400.6127	0.00				
1.5000	0.3697	154868.	7035.	-0.01113	0.00	1.57E+09
-84.0782	409.3061	0.00				
1.6500	0.3499	168985.	6871.	-0.01094	0.00	1.56E+09
-98.2720	505.5795	0.00				
1.8000	0.3304	182756.	6680.	-0.01074	0.00	1.55E+09
-114.0919	621.6569	0.00				
1.9500	0.3112	196126.	6459.	-0.01052	0.00	1.55E+09
-131.0591	758.0310	0.00				
2.1000	0.2925	209039.	6207.	-0.01028	0.00	1.54E+09
-149.1730	918.0562	0.00				
2.2500	0.2742	221433.	5921.	-0.01003	0.00	1.54E+09
-168.4302	1106.	0.00				
2.4000	0.2564	233245.	5600.	-0.00977	0.00	1.53E+09
-188.8209	1326.	0.00				
2.5500	0.2390	244405.	5240.	-0.00948	0.00	1.53E+09
-210.3188	1584.	0.00				
2.7000	0.2222	254842.	4842.	-0.00919	0.00	1.52E+09
-232.8624	1886.	0.00				
2.8500	0.2059	264481.	4401.	-0.00888	0.00	1.52E+09
-256.3231	2240.	0.00				
3.0000	0.1902	273245.	3918.	-0.00856	0.00	1.52E+09
-280.4593	2654.	0.00				
3.1500	0.1751	281053.	3391.	-0.00824	0.00	1.52E+09
-304.8589	3134.	0.00				
3.3000	0.1606	287826.	2821.	-0.00790	0.00	1.51E+09
-328.8820	3686.	0.00				
3.4500	0.1467	293484.	2209.	-0.00755	0.00	1.51E+09
-351.6226	4315.	0.00				
3.6000	0.1334	297952.	1557.	-0.00720	0.00	1.51E+09
-371.9167	5018.	0.00				
3.7500	0.1208	301164.	873.1121	-0.00684	0.00	1.51E+09
-388.4177	5790.	0.00				
3.9000	0.1088	303066.	163.7626	-0.00648	0.00	1.51E+09
-399.7485	6616.	0.00				

4.0500	0.09742	303621.	-560.2479	-0.00612	0.00	1.51E+09	-404.7077	7478.	0.00
4.2000	0.08673	302812.	-1287.	-0.00576	0.00	1.51E+09	-402.4803	8353.	0.00
4.3500	0.07669	300647.	-2002.	-0.00540	0.00	1.51E+09	-392.7884	9220.	0.00
4.5000	0.06729	297158.	-2694.	-0.00504	0.00	1.51E+09	-375.9356	10056.	0.00
4.6500	0.05853	292400.	-3350.	-0.00469	0.00	1.51E+09	-352.7345	10848.	0.00
4.8000	0.05040	286449.	-3959.	-0.00435	0.00	1.51E+09	-324.3520	11585.	0.00
4.9500	0.04287	279398.	-4514.	-0.00401	0.00	1.52E+09	-292.1227	12264.	0.00
5.1000	0.03595	271353.	-5009.	-0.00369	0.00	1.52E+09	-257.3820	12887.	0.00
5.2500	0.02961	262428.	-5440.	-0.00337	0.00	1.52E+09	-221.3461	13458.	0.00
5.4000	0.02382	252741.	-5805.	-0.00307	0.00	1.52E+09	-185.0468	13983.	0.00
5.5500	0.01857	242411.	-6106.	-0.00277	0.00	1.53E+09	-149.3096	14472.	0.00
5.7000	0.01384	231556.	-6344.	-0.00249	0.00	1.53E+09	-114.7635	14931.	0.00
5.8500	0.00959	220291.	-6521.	-0.00223	0.00	1.54E+09	-81.8665	15366.	0.00
6.0000	0.00581	208723.	-6641.	-0.00198	0.00	1.54E+09	-50.9363	15784.	0.00
6.1500	0.00247	196955.	-6706.	-0.00174	0.00	1.55E+09	-22.1812	16190.	0.00
6.3000	-4.64E-04	185082.	-6722.	-0.00152	0.00	1.55E+09	4.2744	16587.	0.00
6.4500	-0.00301	173192.	-6693.	-0.00131	0.00	1.56E+09	28.3678	16979.	0.00
6.6000	-0.00519	161365.	-6622.	-0.00112	0.00	1.56E+09	50.0820	17367.	0.00
6.7500	-0.00704	149673.	-6515.	-9.41E-04	0.00	1.57E+09	69.4334	17755.	0.00
6.9000	-0.00858	138182.	-6375.	-7.77E-04	0.00	1.58E+09	86.4622	18142.	0.00
7.0500	-0.00983	126948.	-6206.	-6.26E-04	0.00	1.58E+09	101.2398	18529.	0.00
7.2000	-0.01083	116022.	-6012.	-4.87E-04	0.00	1.58E+09	113.8300	18918.	0.00
7.3500	-0.01159	105445.	-5798.	-3.61E-04	0.00	1.58E+09	124.3082	19308.	0.00
7.5000	-0.01213	95254.	-5566.	-2.47E-04	0.00	1.58E+09	132.7595	19699.	0.00
7.6500	-0.01248	85477.	-5322.	-1.44E-04	0.00	1.58E+09	139.2774	20092.	0.00

7.8000	-0.01265	76137.	-5067.	-5.19E-05	0.00	1.58E+09	143.9622	20487.	0.00
7.9500	-0.01266	67252.	-4805.	2.98E-05	0.00	1.58E+09	146.9201	20882.	0.00
8.1000	-0.01254	58831.	-4539.	1.02E-04	0.00	1.58E+09	148.2624	21279.	0.00
8.2500	-0.01230	50881.	-4273.	1.64E-04	0.00	1.58E+09	148.1042	21676.	0.00
8.4000	-0.01195	43403.	-4007.	2.18E-04	0.00	1.58E+09	146.5637	22074.	0.00
8.5500	-0.01151	36392.	-3746.	2.63E-04	0.00	1.58E+09	143.7615	22473.	0.00
8.7000	-0.01100	29841.	-3491.	3.01E-04	0.00	1.58E+09	139.8199	22872.	0.00
8.8500	-0.01043	23739.	-3244.	3.31E-04	0.00	1.58E+09	134.8616	23271.	0.00
9.0000	-0.00981	18069.	-3006.	3.55E-04	0.00	1.58E+09	129.0098	23669.	0.00
9.1500	-0.00915	12814.	-2780.	3.73E-04	0.00	1.58E+09	122.3870	24068.	0.00
9.3000	-0.00847	7954.	-2566.	3.85E-04	0.00	1.58E+09	115.1145	24467.	0.00
9.4500	-0.00777	3466.	-2366.	3.91E-04	0.00	1.58E+09	107.3108	24864.	0.00
9.6000	-0.00706	-675.7766	-2180.	3.93E-04	0.00	1.58E+09	99.0974	25262.	0.00
9.7500	-0.00635	-4496.	-2009.	3.90E-04	0.00	1.58E+09	90.5905	25659.	0.00
9.9000	-0.00566	-8022.	-1854.	3.83E-04	0.00	1.58E+09	81.9044	26056.	0.00
10.0500	-0.00498	-11281.	-1715.	3.72E-04	0.00	1.58E+09	73.1518	26453.	0.00
10.2000	-0.00432	-14302.	-1591.	3.57E-04	0.00	1.58E+09	64.4433	26850.	0.00
10.3500	-0.00369	-17111.	-1482.	3.39E-04	0.00	1.58E+09	55.8884	27246.	0.00
10.5000	-0.00310	-19736.	-1389.	3.18E-04	0.00	1.58E+09	47.5951	27642.	0.00
10.6500	-0.00255	-22204.	-1311.	2.94E-04	0.00	1.58E+09	39.6706	28038.	0.00
10.8000	-0.00204	-24540.	-1246.	2.68E-04	0.00	1.58E+09	32.2218	28434.	0.00
10.9500	-0.00158	-26767.	-1194.	2.38E-04	0.00	1.58E+09	25.3556	28829.	0.00
11.1000	-0.00118	-28908.	-896.3686	2.07E-04	0.00	1.58E+09	305.6691	465760.	0.00
11.2500	-8.39E-04	-30054.	-294.3355	1.73E-04	0.00	1.58E+09	363.2565	779566.	0.00
11.4000	-5.58E-04	-30018.	395.0257	1.39E-04	0.00	1.58E+09	402.7003	1299492.	0.00

```
   11.5500  -3.38E-04    -28672.       1137.   1.06E-04       0.00   1.58E+09
421.3032   2241079.       0.00
   11.7000  -1.78E-04    -25956.       1889.   7.45E-05       0.00   1.58E+09
414.8005   4200819.       0.00
   11.8500  -7.03E-05    -21892.       2599.   4.72E-05       0.00   1.58E+09
373.5539   9565441.       0.00
   12.0000  -7.73E-06    -16615.       3152.   2.53E-05       0.00   1.58E+09
241.6557   5.63E+07       0.00
   12.1500   2.08E-05    -10551.       3063.   9.83E-06       0.00   1.58E+09
-340.4470   2.95E+07       0.00
   12.3000   2.77E-05     -5589.       2396.   6.42E-07       0.00   1.58E+09
-401.1089   2.61E+07       0.00
   12.4500   2.31E-05     -1926.       1660.  -3.64E-06       0.00   1.58E+09
-417.1134   3.25E+07       0.00
   12.6000   1.46E-05   386.5890   922.5953  -4.51E-06       0.00   1.58E+09
-401.7999   4.96E+07       0.00
   12.7500   6.85E-06      1397.   243.9058  -3.50E-06       0.00   1.58E+09
-352.2996   9.26E+07       0.00
   12.9000   1.98E-06      1266.  -168.2747  -1.98E-06       0.00   1.58E+09
-105.6788   9.58E+07       0.00
   13.0500  -2.85E-07   791.7446  -249.7221  -8.10E-07       0.00   1.58E+09
15.1817   9.58E+07       0.00
   13.2000  -9.32E-07   366.8909  -191.3987  -1.50E-07       0.00   1.58E+09
49.6222   9.58E+07       0.00
   13.3500  -8.27E-07   102.7528  -107.1243   1.17E-07       0.00   1.58E+09
44.0160   9.58E+07       0.00
   13.5000  -5.11E-07   -18.7904   -43.0351   1.65E-07       0.00   1.58E+09
27.1942   9.58E+07       0.00
   13.6500  -2.33E-07   -52.2212    -7.3793   1.24E-07       0.00   1.58E+09
12.4234   9.58E+07       0.00
   13.8000  -6.30E-08   -45.3917     6.8191   6.88E-08       0.00   1.58E+09
3.3526   9.58E+07      0.00
   13.9500   1.43E-08   -27.6922     9.1493   2.72E-08       0.00   1.58E+09
-0.7636   9.58E+07      0.00
   14.1000   3.49E-08   -12.4621     6.7907   4.31E-09       0.00   1.58E+09
-1.8571   9.58E+07      0.00
   14.2500   2.99E-08    -3.2470     3.6878  -4.63E-09       0.00   1.58E+09
-1.5905   9.58E+07      0.00
   14.4000   1.82E-08     0.8154     1.3840  -6.02E-09       0.00   1.58E+09
-0.9694   9.58E+07      0.00
   14.5500   8.21E-09     1.7371     0.1180  -4.56E-09       0.00   1.58E+09
-0.4373   9.58E+07      0.00
   14.7000   1.78E-09     1.2417    -0.3608  -2.87E-09       0.00   1.58E+09
-0.09476   9.58E+07      0.00
   14.8500  -2.11E-09     0.4391    -0.3451  -1.91E-09       0.00   1.58E+09
0.1122   9.58E+07      0.00
   15.0000  -5.09E-09       0.00       0.00  -1.66E-09       0.00   1.58E+09
0.2712   4.79E+07      0.00
```

* This analysis computed pile response using nonlinear moment-curvature rela-

tionships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

```
Output Summary for Load Case No. 3:

Pile-head deflection             =     0.58092367 inches
Computed slope at pile head      =    -0.01203153 radians
Maximum bending moment           =        303621. inch-lbs
Maximum shear force              =          8000. lbs
Depth of maximum bending moment  =     4.05000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             19
Number of zero deflection points =              5



--------------------------------------------------------------------------------
                 Computed Values of Pile Loading and Deflection
                   for Lateral Loading for Load Case Number 4
--------------------------------------------------------------------------------

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head                                =       7500.0 lbs
Applied moment at pile head                             =          0.0 in-lbs
Axial thrust load on pile head                          =      -7000.0 lbs

   Depth    Deflect.    Bending     Shear      Slope      Total     Bending   Soil
Res.  Soil Spr.  Distrib.
     X          y       Moment      Force        S       Stress    Stiffness      p
      Es*H     Lat. Load
   feet      inches     in-lbs       lbs      radians     psi*      lb-in^2
lb/inch    lb/inch    lb/inch
---------- ---------- ---------- ---------- ---------- ---------- ----------
---------- ---------- ----------
      0.00     0.4643   5.23E-07      7500.   -0.00989       0.00   1.61E+09
0.00       0.00       0.00
    0.1500     0.4465     13375.      7491.   -0.00989       0.00   1.61E+09
-9.9078    39.9420       0.00
    0.3000     0.4287     26719.      7463.   -0.00986       0.00   1.61E+09
-21.6193    90.7702      0.00
    0.4500     0.4110     39993.      7412.   -0.00983       0.00   1.60E+09
-34.3332   150.3675      0.00
    0.6000     0.3933     53156.      7339.   -0.00977       0.00   1.42E+09
-47.2481   216.2126      0.00
    0.7500     0.3758     66167.      7243.   -0.00969       0.00   1.43E+09
```

```
-59.5624   285.2735       0.00
    0.9000     0.3584     78985.       7126.   -0.00960       0.00   1.43E+09
-70.4749   353.8985       0.00
    1.0500     0.3413     91577.       6991.   -0.00949       0.00   1.43E+09
-79.1842   417.6680       0.00
    1.2000     0.3243    103914.       6843.   -0.00937       0.00   1.44E+09
-84.8888   471.2145       0.00
    1.3500     0.3075    115977.       6689.   -0.00923       0.00   1.44E+09
-86.7875   507.9988       0.00
    1.5000     0.2910    127761.       6535.   -0.00908       0.00   1.44E+09
-84.0788   520.0307       0.00
    1.6500     0.2748    139275.       6371.   -0.00891       0.00   1.44E+09
-98.2725   643.6560       0.00
    1.8000     0.2589    150472.       6180.   -0.00873       0.00   1.44E+09
-114.0914   793.1211       0.00
    1.9500     0.2434    161302.       5959.   -0.00854       0.00   1.44E+09
-131.0540   969.2500       0.00
    2.1000     0.2282    171710.       5707.   -0.00833       0.00   1.44E+09
-149.1513      1177.       0.00
    2.2500     0.2134    181638.       5421.   -0.00811       0.00   1.44E+09
-168.3588      1420.       0.00
    2.4000     0.1990    191023.       5100.   -0.00788       0.00   1.44E+09
-188.6191      1706.       0.00
    2.5500     0.1850    199799.       4741.   -0.00763       0.00   1.44E+09
-209.8140      2041.       0.00
    2.7000     0.1715    207900.       4344.   -0.00738       0.00   1.44E+09
-231.7242      2432.       0.00
    2.8500     0.1585    215252.       3907.   -0.00711       0.00   1.44E+09
-253.9816      2885.       0.00
    3.0000     0.1459    221785.       3430.   -0.00684       0.00   1.44E+09
-276.0241      3405.       0.00
    3.1500     0.1338    227427.       2914.   -0.00656       0.00   1.44E+09
-297.0694      3995.       0.00
    3.3000     0.1223    232111.       2362.   -0.00627       0.00   1.44E+09
-316.1286      4653.       0.00
    3.4500     0.1113    235773.       1779.   -0.00598       0.00   1.44E+09
-332.0732      5372.       0.00
    3.6000     0.1008    238364.       1171.   -0.00569       0.00   1.44E+09
-343.7608      6141.       0.00
    3.7500    0.09079    239844.    546.0484   -0.00539       0.00   1.44E+09
-350.1969      6943.       0.00
    3.9000    0.08136    240194.    -84.7542   -0.00509       0.00   1.44E+09
-350.6949      7758.       0.00
    4.0500    0.07248    239411.   -710.8692   -0.00479       0.00   1.44E+09
-344.9884      8568.       0.00
    4.2000    0.06413    237514.      -1321.   -0.00449       0.00   1.44E+09
-333.2638      9354.       0.00
    4.3500    0.05631    234541.      -1906.   -0.00420       0.00   1.44E+09
-316.1077     10104.       0.00
    4.5000    0.04903    230548.      -2455.   -0.00390       0.00   1.44E+09
```

-294.3941	10809.	0.00				
4.6500	0.04226	225604.	-2962.	-0.00362	0.00	1.44E+09
-269.1479	11465.	0.00				
4.8000	0.03599	219792.	-3422.	-0.00334	0.00	1.44E+09
-241.4192	12073.	0.00				
4.9500	0.03022	213201.	-3830.	-0.00307	0.00	1.44E+09
-212.1896	12637.	0.00				
5.1000	0.02494	205926.	-4185.	-0.00281	0.00	1.44E+09
-182.3161	13161.	0.00				
5.2500	0.02011	198064.	-4487.	-0.00256	0.00	1.44E+09
-152.5082	13651.	0.00				
5.4000	0.01573	189710.	-4735.	-0.00232	0.00	1.44E+09
-123.3284	14114.	0.00				
5.5500	0.01177	180960.	-4931.	-0.00208	0.00	1.44E+09
-95.2066	14556.	0.00				
5.7000	0.00823	171904.	-5079.	-0.00186	0.00	1.44E+09
-68.4596	14980.	0.00				
5.8500	0.00507	162630.	-5179.	-0.00165	0.00	1.44E+09
-43.3132	15392.	0.00				
6.0000	0.00227	153217.	-5236.	-0.00146	0.00	1.44E+09
-19.9208	15795.	0.00				
6.1500	-1.80E-04	143742.	-5253.	-0.00127	0.00	1.44E+09
1.6196	16192.	0.00				
6.3000	-0.00231	134275.	-5232.	-0.00110	0.00	1.44E+09
21.2530	16585.	0.00				
6.4500	-0.00413	124879.	-5178.	-9.35E-04	0.00	1.44E+09
38.9568	16976.	0.00				
6.6000	-0.00567	115611.	-5094.	-7.85E-04	0.00	1.44E+09
54.7338	17366.	0.00				
6.7500	-0.00696	106522.	-4983.	-6.45E-04	0.00	1.44E+09
68.6059	17755.	0.00				
6.9000	-0.00800	97657.	-4848.	-5.17E-04	0.00	1.43E+09
80.6109	18145.	0.00				
7.0500	-0.00882	89055.	-4694.	-4.00E-04	0.00	1.43E+09
90.7987	18535.	0.00				
7.2000	-0.00944	80748.	-4523.	-2.93E-04	0.00	1.43E+09
99.2297	18927.	0.00				
7.3500	-0.00987	72765.	-4338.	-1.97E-04	0.00	1.43E+09
105.9726	19320.	0.00				
7.5000	-0.01014	65125.	-4143.	-1.10E-04	0.00	1.42E+09
111.1034	19714.	0.00				
7.6500	-0.01027	57847.	-3940.	-3.18E-05	0.00	1.42E+09
114.7038	20108.	0.00				
7.8000	-0.01026	50941.	-3731.	3.72E-05	0.00	1.42E+09
116.8608	20504.	0.00				
7.9500	-0.01013	44415.	-3520.	9.61E-05	0.00	1.51E+09
117.6654	20900.	0.00				
8.1000	-0.00991	38271.	-3309.	1.44E-04	0.00	1.60E+09
117.2885	21297.	0.00				
8.2500	-0.00962	32507.	-3099.	1.84E-04	0.00	1.60E+09

```
115.8849     21694.        0.00
    8.4000   -0.00925      27119.      -2892.   2.17E-04        0.00   1.61E+09
113.5457     22091.        0.00
    8.5500   -0.00883      22099.      -2691.   2.45E-04        0.00   1.61E+09
110.3628     22489.        0.00
    8.7000   -0.00837      17438.      -2496.   2.67E-04        0.00   1.61E+09
106.4284     22886.        0.00
    8.8500   -0.00787      13121.      -2308.   2.84E-04        0.00   1.61E+09
101.8342     23284.        0.00
    9.0000   -0.00735       9135.      -2130.   2.97E-04        0.00   1.61E+09
96.6715     23681.        0.00
    9.1500   -0.00681       5461.      -1961.   3.05E-04        0.00   1.61E+09
91.0300     24078.        0.00
    9.3000   -0.00625       2083.      -1802.   3.09E-04        0.00   1.61E+09
84.9983     24475.        0.00
    9.4500   -0.00569      -1019.      -1655.   3.10E-04        0.00   1.61E+09
78.6628     24872.        0.00
    9.6000   -0.00514      -3867.      -1519.   3.07E-04        0.00   1.61E+09
72.1099     25268.        0.00
    9.7500   -0.00459      -6482.      -1396.   3.01E-04        0.00   1.61E+09
65.4229     25665.        0.00
    9.9000   -0.00405      -8884.      -1284.   2.92E-04        0.00   1.61E+09
58.6833     26061.        0.00
   10.0500   -0.00354     -11096.      -1184.   2.81E-04        0.00   1.61E+09
51.9713     26457.        0.00
   10.2000   -0.00304     -13141.      -1097.   2.68E-04        0.00   1.61E+09
45.3653     26853.        0.00
   10.3500   -0.00257     -15038.      -1021.   2.52E-04        0.00   1.61E+09
38.9427     27248.        0.00
   10.5000   -0.00213     -16809.   -956.3217   2.34E-04        0.00   1.61E+09
32.7799     27644.        0.00
   10.6500   -0.00173     -18475.   -902.5623   2.14E-04        0.00   1.61E+09
26.9527     28039.        0.00
   10.8000   -0.00136     -20053.   -858.9218   1.93E-04        0.00   1.61E+09
21.5367     28435.        0.00
   10.9500   -0.00104     -21562.   -824.5918   1.69E-04        0.00   1.61E+09
16.6076     28830.        0.00
   11.1000   -7.54E-04    -23017.   -563.7621   1.44E-04        0.00   1.61E+09
273.2031    652233.        0.00
   11.2500   -5.17E-04    -23588.    -28.1441   1.18E-04        0.00   1.61E+09
321.9280   1119773.        0.00
   11.4000   -3.29E-04    -23116.    579.0890   9.20E-05        0.00   1.61E+09
352.7755   1932392.        0.00
   11.5500   -1.86E-04    -21501.       1223.   6.70E-05        0.00   1.61E+09
362.8994   3504972.        0.00
   11.7000   -8.75E-05    -18711.       1862.   4.44E-05        0.00   1.61E+09
347.4053   7145198.        0.00
   11.8500   -2.64E-05    -14795.       2438.   2.57E-05        0.00   1.61E+09
292.3711   1.99E+07        0.00
   12.0000    4.84E-06     -9932.       2547.   1.18E-05        0.00   1.61E+09
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-171.3742   6.38E+07       0.00
   12.1500   1.61E-05     -5625.      2105.   3.08E-06       0.00   1.61E+09
-319.4829   3.58E+07       0.00
   12.3000   1.59E-05     -2353.      1503.  -1.39E-06       0.00   1.61E+09
-349.5193   3.95E+07       0.00
   12.4500   1.10E-05  -213.0218   876.4546  -2.83E-06       0.00   1.61E+09
-346.9681   5.66E+07       0.00
   12.6000   5.73E-06   802.4711   304.5006  -2.50E-06       0.00   1.61E+09
-288.5364   9.06E+07       0.00
   12.7500   2.05E-06   883.1175   -53.2510  -1.55E-06       0.00   1.61E+09
-108.9654   9.58E+07       0.00
   12.9000   1.39E-07   610.7283  -157.9946  -7.17E-07       0.00   1.61E+09
-7.4163   9.58E+07       0.00
   13.0500  -5.36E-07   314.3190  -138.9960  -1.99E-07       0.00   1.61E+09
28.5258   9.58E+07       0.00
   13.2000  -5.77E-07   110.3377   -85.6905   3.91E-08       0.00   1.61E+09
30.7025   9.58E+07       0.00
   13.3500  -3.95E-07     5.8342   -39.1346   1.04E-07       0.00   1.61E+09
21.0263   9.58E+07       0.00
   13.5000  -2.01E-07   -30.5441   -10.5599   9.04E-08       0.00   1.61E+09
10.7233   9.58E+07       0.00
   13.6500  -6.95E-08   -32.1793     2.4224   5.52E-08       0.00   1.61E+09
3.7015   9.58E+07       0.00
   13.8000  -2.56E-09   -21.8220     5.8767   2.50E-08       0.00   1.61E+09
0.1365   9.58E+07       0.00
   13.9500   2.04E-08   -11.0227     5.0238   6.56E-09       0.00   1.61E+09
-1.0842   9.58E+07       0.00
   14.1000   2.10E-08    -3.7363     3.0392  -1.71E-09       0.00   1.61E+09
-1.1209   9.58E+07       0.00
   14.2500   1.42E-08   -0.08159     1.3499  -3.85E-09       0.00   1.61E+09
-0.7562   9.58E+07       0.00
   14.4000   7.19E-09     1.1232     0.3249  -3.27E-09       0.00   1.61E+09
-0.3827   9.58E+07       0.00
   14.5500   2.44E-09     1.0881    -0.1364  -2.03E-09       0.00   1.61E+09
-0.1299   9.58E+07       0.00
   14.7000  -1.14E-10     0.6322    -0.2478  -1.06E-09       0.00   1.61E+09
0.00607   9.58E+07       0.00
   14.8500  -1.39E-09     0.1961    -0.1756  -6.00E-10       0.00   1.61E+09
0.07409   9.58E+07       0.00
   15.0000  -2.27E-09       0.00       0.00  -4.90E-10       0.00   1.61E+09
0.1210   4.79E+07       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.
```

Output Summary for Load Case No. 4:

Pile-head deflection = 0.46430448 inches
Computed slope at pile head = -0.00989268 radians
Maximum bending moment = 240194. inch-lbs
Maximum shear force = 7500. lbs
Depth of maximum bending moment = 3.90000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 18
Number of zero deflection points = 5

Summary of Pile-head Responses for Conventional Analyses

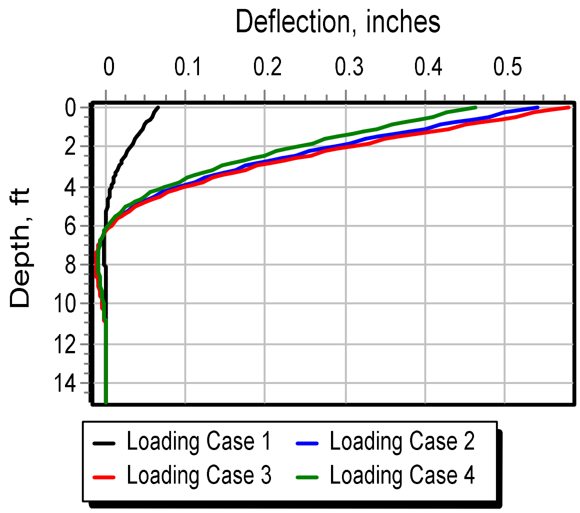
Definitions of Pile-head Loading Conditions:

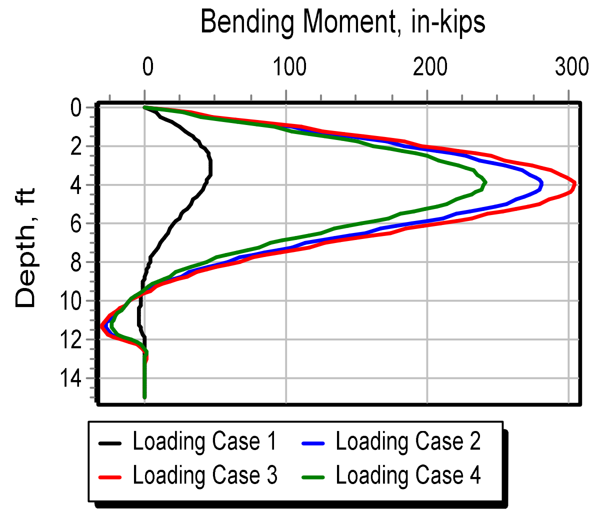
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

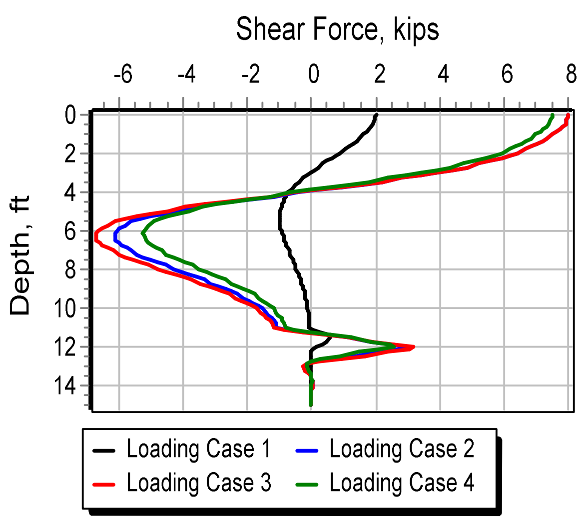
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	2000.	M, in-lb	0.00	80000.	0.06605	-0.00164	2000.	46688.
2	V, lb	8000.	M, in-lb	0.00	32500.	0.5417	-0.01130	8000.	280003.
3	V, lb	8000.	M, in-lb	0.00	80000.	0.5809	-0.01203	8000.	303621.
4	V, lb	7500.	M, in-lb	0.00	-7000.	0.4643	-0.00989	7500.	240194.

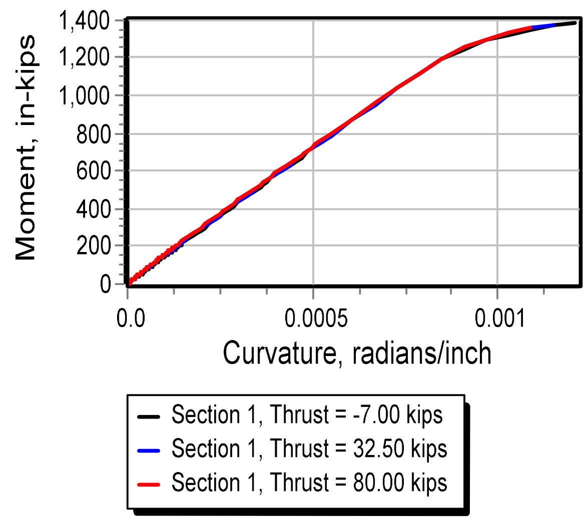
Maximum pile-head deflection = 0.5809236698 inches
Maximum pile-head rotation = -0.0120315321 radians = -0.689356 deg.

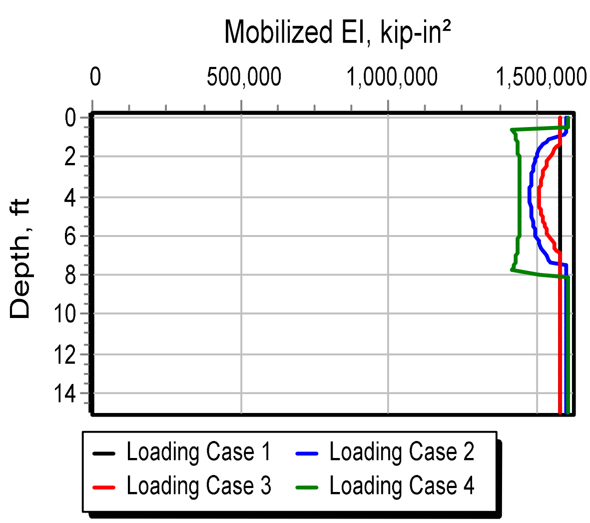
The analysis ended normally.

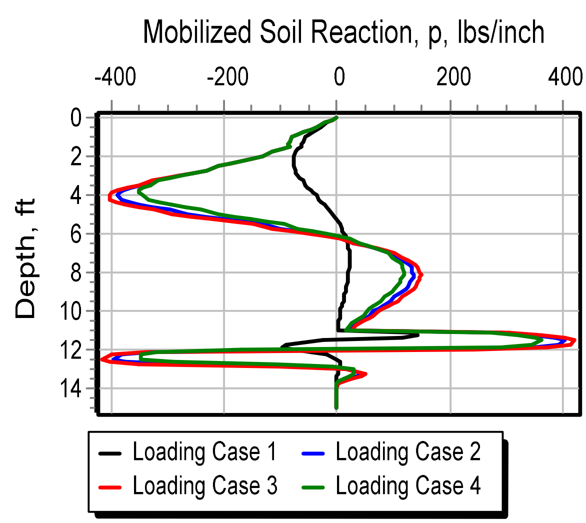

Deflection, inches
0 0.1 0.2 0.3 0.4 0.5
Depth, ft
0 2 4 6 8 10 12 14
Loading Case 1
Loading Case 2
Loading Case 3
Loading Case 4


Bending Moment, in-kips
0 100 200 300
Depth, ft
0 2 4 6 8 10 12 14
Loading Case 1
Loading Case 2
Loading Case 3
Loading Case 4


Shear Force, kips
-6 -4 -2 0 2 4 6 8
Depth, ft
0 2 4 6 8 10 12 14
Loading Case 1
Loading Case 2
Loading Case 3
Loading Case 4


Moment, in-kips
1,400 1,200 1,000 800 600 400 200 0
0.0 0.0005 0.001
Curvature, radians/inch
Section 1, Thrust = -7.00 kips
Section 1, Thrust = 32.50 kips
Section 1, Thrust = 80.00 kips


Mobilized EI, kip-in²
0 500,000 1,000,000 1,500,000
Depth, ft
0 2 4 6 8 10 12 14
Loading Case 1
Loading Case 2
Loading Case 3
Loading Case 4


Mobilized Soil Reaction, p, lbs/inch
-400 -200 0 200 400
Depth, ft
0 2 4 6 8 10 12 14
Loading Case 1
Loading Case 2
Loading Case 3
Loading Case 4

verdantas

CALCULATIONS

Date:	10/17/2024	**Prepared by:**	CJVH	10/17/2024
Project No.:	16667	**Reviewed by:**	MCP	11/26/2024
Subject:	Micropile Calculation - Exit Flume: Column Support	**Checked by:**	CJS	12/2/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

The purpose of this analysis was to perform structural checks for the selected micropile design section based on the lateral response from the LPile analyses. This was an iterative design process and only the final iteration is presented herein. This design check generally follows the procedure outlined in Reference 1.

Calculated Cells   Input Parameters

References:

1. Sabatini et. al. (2005). "Micropile Design and Construction (Reference Manual for NHI Course 132078)," National Highway Institute, Washington D.C.

Assumptions:

1. Micropiles are adequately spaced such that there are not group effects (i.e., at least 30 inches or 3 micropile diameters, whichever is greater).

2. Assume initial casing has a 7 inch outside diameter, 0.5 inch casing wall thickness, and steel with 80ksi yield stress. There is little known about the Site's corrosion potential, so it is assumed that the Site will have aggressive ground conditions. Therefore, 0.063 inches of steel loss is conservatively assumed (per Reference 1) on the outside of the casing during the design life, reducing the outside casing diameter to 6.87 inches and wall thickness to 0.44 inch.

3. From structural analysis:
Maximum compressive load = 80 kips
Maximum tensile load = 7 kips
Maximum lateral load = 8 kips
Maximum bending moment from LPILE analysis = 304 in-kips

Calculation:

1. Select micropile diameter and material properties

Steel Casing

Casing Outside Diameter, OD =	6.874	in	(with corrosion reduction as stated in Assumption 2)
Wall Thickness =	0.437	in	(with corrosion reduction as stated in Assumption 2)
Casing Inside Diameter, ID =	6	in	
Area of Steel Casing, A_{casing} =	8.8	in^2	
Nomial Yield Stress $F_{y\text{-}casing}$=	80	ksi	(assumed, typical for micropile design and construction)

Reinforcing Bar

Steel Bar Size =	#10		(#10 threadbar, selected based on preliminary analyses)
Steel Bar Diameter =	1.43	in	(#10 threadbar, selected based on preliminary analyses)
Area of Steel Bar, A_{bar} =	1.27	in^2	(#10 threadbar, selected based on preliminary analyses)
Nomial Yield Stress $F_{y\text{-}bar}$=	75	ksi	(assumed, typical for micropile design and construction)

Grout Strength

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	(assumed, typical for micropile design and construction)
Drill Hole Diameter, Db=	7	in	(assumed, based on uncorroded casing diameter)
Area of Grout, A_{grout} =	28.4	in^2	(drill hole area minus steel casing and threadbar areas)

2. Check strain compatibility of Grout, Casing and Reinforcing Bar

According to Section 8.16.2.3 of AASHTO (2002), "the maximum usable strain at the extreme concrete compression fiber is equal to 0.003". Therefore, if the grout is limited to a compression strain of 0.003, the steel components must also be limited to this value. The stress in the steel at this strain level is equal to the Young's modulus of steel, E, multiplied by strain (i.e., 0.003). For a typical E for steel of 200,000 MPa (29,000 ksi), the allowable steel yield stress is then 200,000 MPa × 0.003 = 600 MPa (87 ksi). Therefore, the maximum stress based on considerations of grout failure is 600 MPa (87 ksi).

Nomial Yield Stress $F_{y\text{-grout crushing}}$ = 87 ksi

Use minimum yield strength of casing, bar, and grout crushing for structural design check as the minimum yield stress will control the evaluation:

Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ = 75 ksi

3. Evaluate Allowable Compression Load for Cased Length

The following equation factors the strength contributions of the grout, casing and central bar to calculate the allowable compression load for the cased length of the micropile. This does not consider and axial reduction due to structural bending of the micropile.

$$P_{c-allowable} = \left[0.4\, f'_{c-grout} \times A_{grout} + 0.47\, F_{y-steel}\left(A_{bar} + A_{casing}\right)\right]$$ (Eq. 5-1, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	As defined in Step 1 of this calculation
Area of Grout, A_{grout} =	28.4	in^2	As defined in Step 1 of this calculation
Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.43	in^2	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	8.8	in^2	As defined in Step 1 of this calculation
$P_{c\text{-allowable}}$ =	402	kips	Calculated from Eq. 5-1, above.
Max. Applied Compression Load (P_c) =	80	kips	From Structural Engineer's analysis. This is the maximum compression load.

The allowable compression load is significantly larger than the applied compression load; therefore, axial failure of the cased micropile section in compression is not expected.

4. Evaluate Allowable Tension Load for Cased Length

The following equation factors the strength contributions casing and central bar to calculate the allowable tension load for the cased length of the micropile. This does not consider and axial reduction due to structural bending of the micropile. Additionally, the contribution of the grout is ignored as it performs poorly in tension and should not be relied upon for design.

$$P_{t-allowable} = 0.55\, F_{y-steel} \times \left(A_{bar} + A_{casing}\right)$$ (Eq. 5-2, Reference 1)

Nominal Yield Stress of Steel, $F_{y\text{-steel}}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.43	in^2	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	8.8	in^2	As defined in Step 1 of this calculation
$P_{t\text{-allowable}}$ =	417	kips	Calculated from Eq. 5-2, above.
Max. Applied Tensile Load (P_t) =	7	kips	From Structural Engineer's analysis. This is the maximum tensile load .

The allowable tensile load is significantly larger than the applied tensile load; therefore, axial failure of the cased micropile section in tension is not expected.

5. Combined Axial Compression and Bending of Cased Length

The following equation (Eq. 5-3) is used to check that the compression and lateral loads applied to the piles do not exceed the structural capacity of the micropile section. This check is performed to confirm the results of the LPile analysis, described in a separate calculation package. This assumes that all of the bending stress is carried by the casing within the cased length of the micropile and ignores the contributions of the central threadbar and grout. The calculated stress ratio in Eq. 5-3 should be maintained below 1.0.

$$\frac{f_a}{F_a} + \frac{f_b}{\left(1 - \frac{f_a}{F_e'}\right) F_b} \leq 1.0$$ (Eq. 5-3, Reference 1)

The following equations are used to support the structural capacity check in Eq. 5-3, above:

Area of casing: $$A_{casing} = \frac{\pi}{4}(OD^2 - ID^2)$$ (Eq. 5-4a, Reference 1)

Section modulus of casing: $$S = \frac{I_{casing}}{(OD/2)}$$ (Eq. 5-4b, Reference 1)

Moment of inertia of casing: $$I_{casing} = \frac{\pi}{64}\left(OD^4 - ID^4\right)$$ (Eq. 5-4c, Reference 1)

Euler's buckling stress: $$F_e' = \frac{\pi^2 E}{FS\,(Kl/r)^2}$$ (Eq. 5-5, Reference 1)

Applied Compresion Load (P_c) =	80	kips	From Structural Engineer's analysis. This is the axial load associated with the largest lateral force in Case 3 from the LPile analysis.
Applied Maximum Moment (M_{max}) =	304	kip-in	Maximum bending moment from LPILE analysis for Case 3.
A_{casing} =	8.8	in^2	Calculated using Eq. 5-4a. Assumed for the corroded casing section described previously.
Casing Outside Diameter, OD =	6.874	in	Calculated in Step 1 of this calculation.
Casing Inside Diameter, ID =	6	in	Calculated in Step 1 of this calculation.
Moment of Inertia, I_{casing} =	46.0	in^4	Calculated from Eq. 5-4c.
Section Modulus, S =	13.4	in^3	Calculated from Eq. 5-4b.
Applied Axial Stress, f_a (P_c/A_{casing})=	9.05	ksi	Calculates the applied axial stress in pile assuming the axial load is fully carried by the casing cross section. This is subsequently used in Eq. 5-3.
Applied Bending Stress, f_b (M_{max}/S)=	22.72	ksi	Calculates the applied bending stress in pile assuming the bending moment is fully carried by the casing cross section. This is subsequently used in Eq. 5-3.
Allowable Axial Stress, F_a (0.47 x $F_{y\text{-}casing}$) =	37.6	ksi	This uses the yield stress of the casing assign in Step 1 of this calculation. This is subsequently used in Eq. 5-3.
Allowable Bending Stress, F_b (0.55 x $F_{y\text{-}casing}$) =	44.0	ksi	This uses the yield stress of the casing assign in Step 1 of this calculation. This is subsequently used in Eq. 5-3.
Elastic Modulus of Steel (E) =	29000	ksi	Assumed for use in Eq. 5-5.
Effective Length Factor, K =	1		Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.
Factor of Safety, FS =	2.12		Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.

Unsupported Length of Micropile, l =	36	in	This is an assumed length over which the micropile could be passing through very weak soils or voids. Based on the boring logs, it is expected that there could be rock or rubble fill on the site but there weren't any large voids encountered. As such, the unsupported length is assumed to be minimal and is conservatively assumed to be 36 inches.
Radius of Gyration of Casing (r), SQRT(I_{casing}/A_{casing}) =	2.3	in	Per Ref. 1, this is typically assumed in micropile design. This is used in Eq 5-5.
Euler Bucking Stress, F'_e =	542	ksi	Calculated using Eq. 5-5 and subsequently used in Eq. 5-3.
Per Eq. 5-3, Ref 1 =	0.766	VALUE IS LESS THAN 1. THE CHECK PASSES.	

As a double check of the combined stress check, the Richards and Rothbauer (Eq. 5-6, below) approach is used. This approach assumes the risk of pile buckling is negligible, but does account for the contribution of the central bar and grout to capacity. As such, if the pile is properly restrained against buckling, it is expected that this check will indicate slighly lower combined stress ratio than the above check.

$$\frac{P_c}{P_{c-allowable}} + \frac{M_{max}}{M_{allowable}} \leq 1.0$$ (Eq. 5-6, Reference 1)

Applied Axial Load (P_c) =	8	kips	From Structural Engineer's analysis. This is the axial load associated with the largest lateral force in Case 3 from the LPile analysis.
$P_{c\text{-allowable}}$ =	402	kips	Previously calculated from Eq. 5-1, above.
Applied Maximum Moment (M_{max}) =	304	kip-in	Maximum bending moment from LPILE analysis for Case 3.
Allowable Moment (Fb x S), M_{allow} =	589	kip-in	
Per Eq. 5-6, Ref 1 =	0.716	VALUE IS LESS THAN 1. THE CHECK PASSES.	

6. Evaluate Allowable Compression Load for Uncased Length

The compression load will be transferred through the cased section and into the uncased section. As such, the allowable compression load for the uncased length must be checked to verify that it is not exceeded.

$$P_{c-allowable} = \left(0.4 f_c' \times A_{grout} + 0.47 F_{y-bar} \times A_{bar}\right)$$ (Eq. 5-7, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	As defined in Step 1 of this calculation
Area of Grout, A_{grout} =	28.4	in^2	As defined in Step 1 of this calculation
Nominal Yield Stress of Bar, $F_{y\text{-bar}}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.27	in^2	As defined in Step 1 of this calculation
$P_{c\text{-allowable}}$ =	90	kips	
Max. Applied Compression Load (P_c) =	80	kips	From Structural Engineer's analysis. This is the maximum compression load.

The allowable compression load is larger than the applied compression load; therefore, axial failure of the uncased micropile section in compression is not expected.

7. Evaluate Allowable Tensile Load for Uncased Length

$$P_{t-allowable} = 0.55 F_{y-bar} \times A_{bar}$$

(Eq. 5-8, Reference 1)

Nominal Yield Stress of Bar, $F_{y\text{-}bar}$ =	75	ksi	As defined in Step 2 of this calculation
Area of Steel Bar, A_{bar} =	1.27	in^2	As defined in Step 1 of this calculation
$P_{t\text{-}allowable}$ =	52	kips	
Max. Applied Tensile Load (P_t) =	7	kips	From Structural Engineer's analysis. This is the maximum tensile load .

The allowable tensile load is larger than the applied tensile load; therefore, axial failure of the uncased micropile section in tension is not expected.

8. Calculate Required Uncased Bond Length

This step calculates the required bond length needed to carry the maximum compression and tensile loads. This calculation assumes that the entire load is carried by the uncased length of the pile.

$$L_b = \frac{P_{G-allowable} \times FS}{\alpha_{bond} \times \pi \times D_b}$$

(Eq. 5-10, Reference 1)

Grout to Ground Ultimate Bond Strength, α_{bond} =	100	psi, (Table 5-3, Reference 1) Assume typical strength of generally weaker rock given the poor quality of rock core collected	
Factor of Safety, FS =	2.5	2.0 is typically used, but increased to account for poor quality rock	
Drill Hole Diameter, D_b=	7	in	Assumed, based on size of the uncorroded casing.
Applied Maximum Tension Load, Pt =	7	kips	From Structural Engineer's analysis. This is the maximum tensile load .
Applied Maximum Compressive Load, Pc =	80	kips	From Structural Engineer's analysis. This is the maximum compression load .

Calculate bond length in compression and tension by substituting Applied Pc and Pt into Eq. 5-10 for $P_{G\text{-}allowable}$.

Lb, tension =	0.7	ft	This is the required bond length required to carry the maximum tensile load.
Lb, compression =	7.6	ft	This is the required bond length required to carry the maximum compression load.

9. Determine ultimate loads for field testing program.

This step calculates the ultimate compression and tensile capacity of the micropile. These are used in developing the field testing program. As such, the initial pre-corrosion casing dimensions are used in this evaluation.

$$P_{ult-compression} = \left[0.85 f'_{c-grout} \times A_{grout} + f_{y-casing} \times A_{casing} + f_{y-bar} \times A_{bar}\right]$$

(Eq. 5-23, Reference 1)

28-day Unconfined Compressive Strength (f'_c) =	4	ksi	As defined in Step 1 of this calculation
Drill Hole Diameter, Db=	7	in	Assumed, based on size of the uncorroded casing.
Casing Outside Diameter, OD =	7	in	Based on size of the uncorroded casing.
Area of Grout, A_{grout} =	27.0	in^2	Drill hole area minus steel casing area (7" OD, Casing)
Nomial Yield Stress $F_{y\text{-}casing}$=	80	ksi	As defined in Step 1 of this calculation
Wall Thickness =	0.5	in	Based on size of the uncorroded casing.
Casing Inside Diameter, ID =	6	in	Based on size of the uncorroded casing.

Area of Steel Casing, A_{casing} =	10.2 in^2	Based on size of the uncorroded casing.
Steel Bar Size =	#10	As defined in Step 1 of this calculation
Steel Bar Diameter =	1.43 in	As defined in Step 1 of this calculation
Area of Steel Bar, A_{bar} =	1.27 in^2	As defined in Step 1 of this calculation
Nomial Yield Stress $F_{y\text{-}bar}$=	75 ksi	As defined in Step 1 of this calculation

$$P_{ult-compression} = 1004 \text{ kips}$$

$$P_{ult-tension} = \left\lfloor f_{y-casing} \times A_{casing} + f_{y-bar} \times A_{bar} \right\rfloor$$ (Eq. 5-24, Reference 1)

Nomial Yield Stress $F_{y\text{-}casing}$=	80 ksi	As defined in Step 1 of this calculation
Area of Steel Casing, A_{casing} =	10.2 in^2	Based on size of the uncorroded casing.
Area of Steel Bar, A_{bar} =	1.27 in^2	As defined in Step 1 of this calculation
Nomial Yield Stress $F_{y\text{-}bar}$=	75 ksi	As defined in Step 1 of this calculation
$P_{ult-tension}$ =	912 kips	

Conclusion:

The following micropile section is recommended to carry the proposed loading conditions (allowing for corrosion):

Casing API N-80 Pipe

Casing Requirements

Casing Outside Diameter, OD = 7 in

Wall Thickness = 0.5 in

Nomial Yield Stress $F_{y\text{-}casing}$= 80 ksi

Casing Length = 15 ft

Threaded casing connections will not be permitted.

Grout/Concrete Requirements

Grout/concrete 28-day Unconfined Compressive Strength (f'_c) = 4 ksi

Reinforcing Core Requirements

Steel Bar Size = #10 DSI Threadbar, Epoxy Coated

Uncased Length

Minimum Uncased Length = 8 ft

Testing Requirements

A minimum of one verification test will be required for the project to demonstrate the micropiles can carry a minimum of 2.5 times the design tension (Design Load = 7 kips) and compression loads (Design Load = 80 kips).

Proof testing on a minimum 5 percent of installed piles (with a minimum of one proof test per substructure unit) are required to demonstrate the micropiles can be loaded to 1.6 times the design tension (Design Load = 7 kips) and compression loads (Design Load = 80 kips).

Pile testing loads may not exceed 80% of the ultimate compression (1004 kips) and tension (912 kips) capacities calculated herein.

Date: 10/30/2024
Project No.: 16667
Subject: Northern Abutment - Rock Dowels
Project Short Title: Woodland Fish Passage Design
Location: Woodland, ME

Prepared by: CJS 10/29/2024
Checked by: MCP 11/21/2024

Purpose:
Design rock dowels to satisfy overturning turning forces of the proposed northern abutment of the proposed access road bridge crossing.

References:

1. Sabatini et. al. (1999). "GEOTECHNICAL ENGINEERING CIRCULAR NO. 4 Ground Anchors and Anchored Systems" Federal Highway Administration, Washington D.C.

2. Williams Form Engineering Corp., Hollow Injection Bar Product Information, accessed on 10/29/2024 <https://www.williamsform.com/threaded-bar/hollow-injection-bar/>

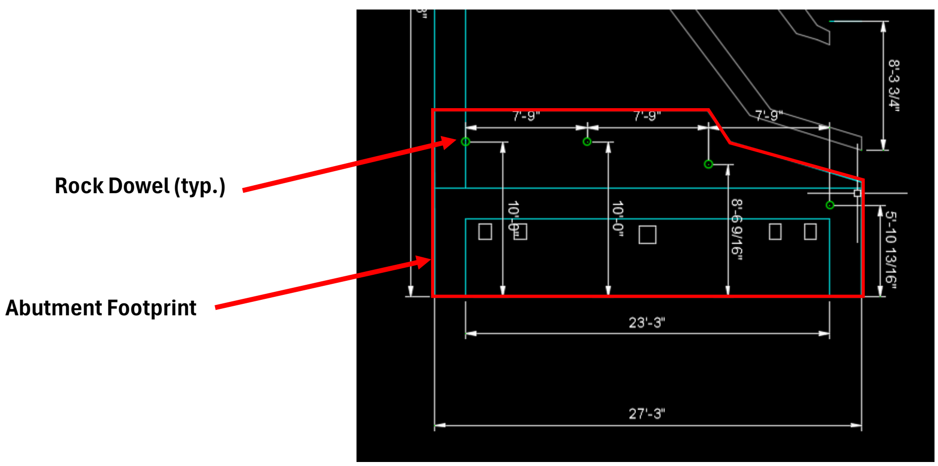
Assumptions:

1. The bedrock will have fractured zones and will not be competent over the full length of the dowel bond.

2. The proposed rock dowel layout is as shown in the layout below.

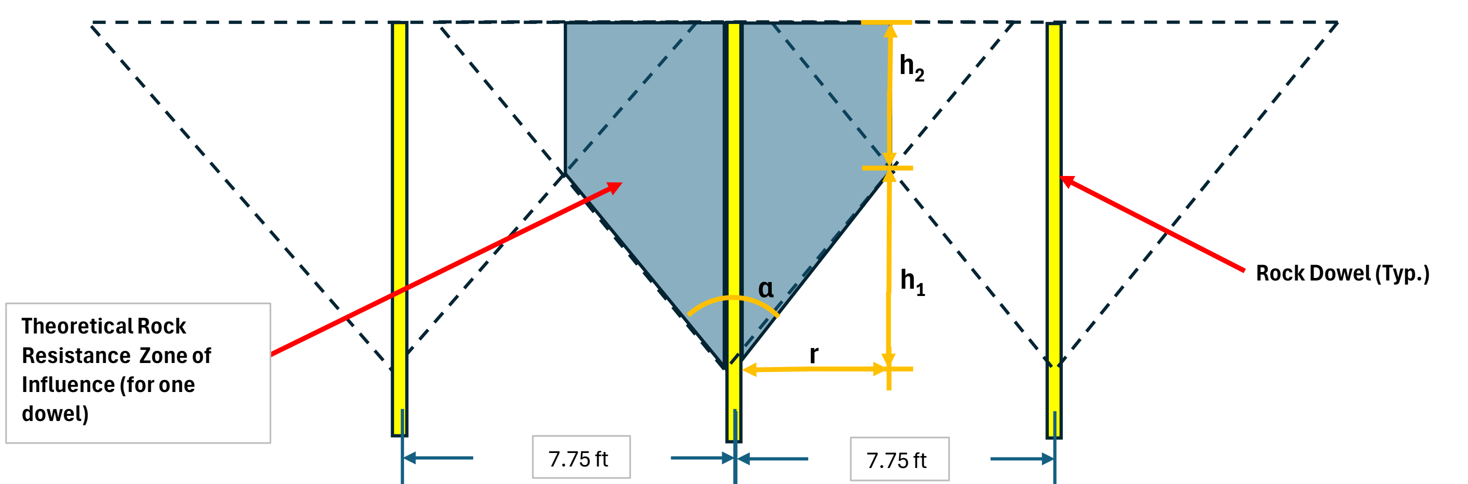
3. Assume the bedrock unity weight is 150 pcf.

4. Shear resistance of bedrock is conservatively assumed to be entirely cohesion (c) = 8,000 psf (c= 1/2 q_u). This is based on a conservaitve allowable bearing resistance of rock of 16,000psf (qu) for very poor quality rock. Refer to Bearing Capacity of Rock calculation for justification.



Calculation:
Calculate the required dowel length accounting for the contributions of weight of rock, internal friction of the rock, and grout/rock bond strength. Consider the overlapping zone of influence from adjacent dowels. This is an iterative process to check rock dowel length until satisfactory geotechnical resistance is acheived.

OVERLAPPING ROCK CONES SCHEMATIC



1) Estimate weight of rock cone against to resist pullout. Break rock within influence zones into two shapes: lower cone where stress envelopes do not overlap and an upper cone within the cone of influence.

Lower Cone

Pullout Angle of Anchor in Rock (a) =	60	degrees	Reference 1, angle for soft, heavily weathered or fissured bedrock.
Height of Lower Cone (h_1) =	6.7	ft	Based on selected pullout angle.
Radius of Cone (r) =	3.9	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Volume of Rock in Cone (V_1) =	105.6	cf	$V_1 = \frac{1}{3}\pi r^2 h_1$

Upper Cylinder

Radius of Cylinder (r) =	3.9	ft	Same radius as for the Lower Cone.
Height of Upper Cylinder (h_2) =	11.1	ft	Vary height of cylinder until required capacity is reached.
Volume of Rock in Cylinder (V_2) =	523.7	cf	$V_2 = \pi r^2 h_2$

Weight of Rock Within Dowel Zone of Influence

Unit Weight of Rock =	150	pcf	Assumption 4
Total Volume of Rock (V_1 + V_2)=	629.2	cf	
Weight of rock =	94382.8	lbs	
	94.4	kips	
Applied Service Load =	94	kips	
FS =	1.0	with rock mass alone	

2) Estimate frictional resistance to rock cone pullout. Calculate surface areas based on the upper cylinder and lower cone dimension defined in Step 1. Assume that the shear resistance is due to the internal cohesion fores of intact bedrock.

Lower Cone

Pullout Angle of Anchor in Rock (a) =	60	degrees	Ref. 1, angle used for soft, heavily weathered or fissured bedrock.
Height of Lower Cone (h_1) =	6.7	ft	Based on selected pullout angle.
Radius of Cone (r) =	3.9	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Calc. Surface Area of Rock in Cone (A_1) =	94.4	cf	$A_1 = \sqrt{h_1^2 + r^2} \times \pi \times r$

Upper Cylinder

Radius of Cone (r) =	3.9	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Height of Upper Cylinder (h_2) =	11.1	ft	Calculated is Step 1.
Calc. Surface Area of Rock in Cone (A_2) =	270.3	cf	$A_2 = 2\pi rh$

Shear Resistance of Rock Within Dowel Zone of Influence

Total Surface Area of Rock (A_1 + A_2)=	364.6	sf	
Shear Strength of Rock =	8000	psf	Assumption 4
Shear Resistance =	2917	kips	

The shear resistance calculated above assumes that the rock acting along the surface area of the cone is fully competent. However, based upon rock core collected there are likely to be zones of low quality/fractured rock. It is anticipated that the bedrock below the river channel, where these dowels will be located, is of higher quality because: 1) the river water has likely scoured poor quality rock and 2) the borings seemed to generally indicate that rock quality improved with depth. As such, conservatively assume that only 10% of the surface area of the rock within the zone of influence is competent enough to provide full cohesional resistance (shear resistance).

Shear Resistance of Rock Within Dowel Zone of Influence (REDUCED)

Area of Rock ([A_1 + A_2]*10%)=	36.5 sf	
Shear Strength of Rock =	8000 psf	Assumption 4
Shear Resistance =	291.7 kips	

3) Calculate geotechnical Factor of Safety against pullout from the combined weight of rock cone and shear resistance of rock.

Weight of rock =	94.4 kips
Shear Resistance =	291.7 kips
Applied Service Load =	94.0 kips
Factor of Safety =	4.1

4) Calculate the required grout bond length. Select bar with an allowable yield strength greater than the applied tensile load.

Bar Diameter (D)=	2.05 inches	Reference 2, T52N B7Y1 Non-Domestic Hollow Injection Bar
Minimum Net Area Through Threads =	1.874 in^2	Reference 2, T52N B7Y1 Non-Domestic Hollow Injection Bar
Minimum Yield Strength (YS)=	164 kips	Reference 2, T52N B7Y1 Non-Domestic Hollow Injection Bar
Allowable Yield Strength (AYS)=	98.4 kips	Assume allowable yield stress of bar is 60% of the yield strength.
Depth of Anchor Bond Zone (h) =	15.0 feet	Assume depth to bottom of rock cone
h/D =	87.7	

Based on Reference 1, for h/D > 15, the dominant failure mechanism is typically at the grout/rock interface. Check grout/rock interface strength.

Ultimate Load transfer value for grout to rock	360 kN/m	(Reference 1, Table 8 slates/hard shales)
	24500 lb/ft	
Bond Length =	20 feet	Assumed to get desired factor of safety
Applied Service Load =	94000 lbs	
FS	5.2	Reference 1, recommends a factor of safety for the ultimate load transfer of 3. However, given the likelihood for fractured rock zones, we will target a factor of safety of 5.

5) Check the required grout/steel bond strength.

Assumed grout compressive stress (fc) =	4000 psi	Assumed
Bond length =	20 ft	Calculated from Step 4.
Ultimate average bond force per in of length of bar =	2214 lbs/in	$U_n = 35\sqrt{f_c}$ ACI 318, Chapter 12
Ultimate average bond force across bond length =	531263 lbs	
	531 kips	
Applied Service Load =	94000 lbs	
Check Factor of Safety =	5.7	

Conclusion:

For dowels to resist an unfactored service of 94 kips (load per dowel), the following minimum requirements will need to be satisfied:

Minimum drill hole diameter =	4 inches
Mimimum Bar Requirement =	T52N B7Y1 Non-Domestic Hollow Injection Bar
Mimimum Bar Area =	1.874 in2
Minimum Yield Strength (YS)=	164 kips
Minimum Grout Compressive Stress (fc)=	4000 psi
Minimum Bond Length =	20 feet

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CALCULATIONS

Date:	12/10/2024	**Prepared by:**	CJS	12/10/2024
Project No.:	16667	**Checked by:**	LTV	12/11/2024
Subject:	Fish Lift - Rock Dowels	**Reviewed by:**	MCP	12/19/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

Design rock dowels to satisfy overturning turning forces of the proposed fish lift ladder.

References:

1. Sabatini et. al. (1999). "GEOTECHNICAL ENGINEERING CIRCULAR NO. 4 Ground Anchors and Anchored Systems" Federal Highway Administration, Washington D.C.

2. Williams Form Engineering Corp., GRADE 75 & GRADE 80 ALL-THREAD BAR, accessed on 12/11/2024 <https://www.williamsform.com/threaded-bar/grade-75-grade-80-all-thread-rebar/>

Assumptions:

1. The bedrock will have fractured zones and will not be competent over the full length of the dowel bond.

2. The proposed rock dowels are assumed to be spaced 10 ft on-center and required to carry 25 kips each.

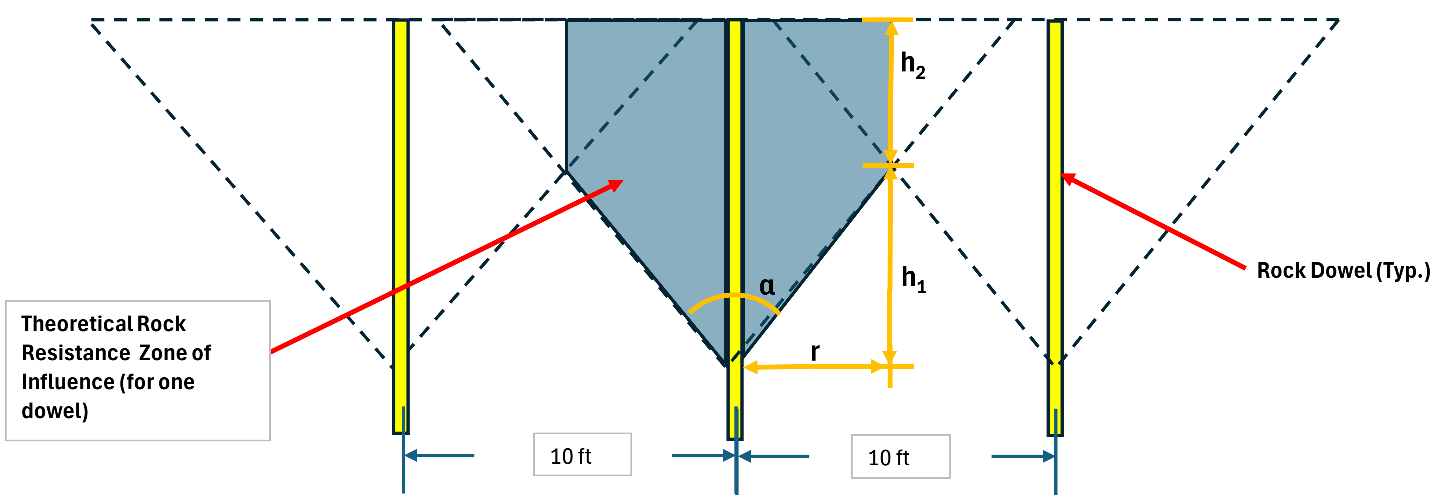
3. Assume the bedrock unity weight is 150 pcf.

4. Shear resistance of bedrock is conservatively assumed to be entirely cohesion (c) = 8,000 psf (c= 1/2 q_u). This is based on a conservaitve allowable bearing resistance of rock of 16,000psf (qu) for very poor quality rock. Refer to Bearing Capacity of Rock calculation for justification.

Calculation:

Calculate the required dowel length accounting for the contributions of weight of rock, internal friction of the rock, and grout/rock bond strength. Consider the overlapping zone of influence from adjacent dowels. This is an iterative process to check rock dowel length until satisfactory geotechnical resistance is acheived.

OVERLAPPING ROCK CONES SCHEMATIC



1) Estimate weight of rock cone against to resist pullout. Break rock within influence zones into two shapes: lower cone where stress envelopes do not overlap and an upper cone within the cone of influence.

Lower Cone

Pullout Angle of Anchor in Rock (a) =	60	degrees	Reference 1, angle for soft, heavily weathered or fissured bedrock.
Height of Lower Cone (h_1) =	8.7	ft	Based on selected pullout angle.
Radius of Cone (r) =	5.0	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Volume of Rock in Cone (V_1) =	227.8	cf	$V_1 = \frac{1}{3}\pi r^2 h_1$

Upper Cylinder

Radius of Cylinder (r) =	5.0	ft	Same radius as for the Lower Cone.
Height of Upper Cylinder (h_2) =	1.3	ft	Vary height of cylinder until required capacity is reached.
Volume of Rock in Cylinder (V_2) =	102.1	cf	$V_2 = \pi r^2 h_2$

Weight of Rock Within Dowel Zone of Influence

Unit Weight of Rock =	150	pcf	Assumption 4
Total Volume of Rock (V_1 + V_2)=	329.9	cf	
Weight of rock =	49480.1	lbs	
	49.5	kips	
Applied Service Load =	25	kips	
FS =	2.0	with rock mass alone	

2) Estimate frictional resistance to rock cone pullout. Calculate surface areas based on the upper cylinder and lower cone dimension defined in Step 1. Assume that the shear resistance is due to the internal cohesion fores of intact bedrock.

Lower Cone

Pullout Angle of Anchor in Rock (a) =	60.0	degrees	Ref. 1, angle used for soft, heavily weathered or fissured bedrock.
Height of Lower Cone (h_1) =	8.7	ft	Based on selected pullout angle.
Radius of Cone (r) =	5.0	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Calc. Surface Area of Rock in Cone (A_1) =	157.6	sf	$A_1 = \sqrt{h_1^2 + r^2} \times \pi \times r$

Upper Cylinder

Radius of Cone (r) =	5.0	ft	Controlled by dowel spacing (i.e., 1/2 the dowel spacing)
Height of Upper Cylinder (h_2) =	1.3	ft	Calculated in Step 1.
Calc. Surface Area of Rock in Cone (A_2) =	40.8	sf	$A_2 = 2\pi rh$

Shear Resistance of Rock Within Dowel Zone of Influence

Total Surface Area of Rock (A_1 + A_2)=	198.5	sf	
Shear Strength of Rock =	8000	psf	Assumption 4
Shear Resistance =	1588	kips	

The shear resistance calculated above assumes that the rock acting along the surface area of the cone is fully competent. However, based upon rock core collected there are likely to be zones of low quality/fractured rock. It is anticipated that the bedrock below the river channel, where these dowels will be located, is of higher quality because: 1) the river water has likely scoured poor quality rock and 2) the borings seemed to generally indicate that rock quality improved with depth. As such, conservatively assume that only 10% of the surface area of the rock within the zone of influence is competent enough to provide full cohesional resistance (shear resistance).

Shear Resistance of Rock Within Dowel Zone of Influence (REDUCED)

Area of Rock ([A_1 + A_2]*10%)=	19.8	sf	
Shear Strength of Rock =	8000	psf	Assumption 4
Shear Resistance =	158.8	kips	

3) Calculate geotechnical Factor of Safety against pullout from the combined weight of rock cone and shear resistance of rock.

Weight of rock =	49.5	kips	
Shear Resistance =	158.8	kips	
Applied Service Load =	25.0	kips	
Factor of Safety =	8.3		

4) Calculate the required grout bond length. Select bar with an allowable yield strength greater than the applied tensile load.

Bar Diameter (D)=	1	inches	Reference 2, Grade 75 All-thread bar
Minimum Net Area Through Threads =	0.79	in^2	Reference 2, Grade 75 All-thread bar
Minimum Yield Strength (YS)=	59	kips	Reference 2, Grade 75 All-thread bar
Allowable Yield Strength (AYS)=	35.4	kips	Assume allowable yield stress of bar is 60% of the yield strength.
Depth of Anchor Bond Zone (h) =	5.0	feet	Assume depth to bottom of rock cone
h/D =	60.0		

Based on Reference 1, for h/D > 15, the dominant failure mechanism is typically at the grout/rock interface. Check grout/rock interface strength.

Ultimate Load transfer value for grout to rock	360	kN/m	(Reference 1, Table 8 slates/hard shales)
	24500	lb/ft	
Bond Length =	10	feet	Assumed to get desired factor of safety
Applied Service Load =	25000	lbs	
FS	9.8		Reference 1, recommends a factor of safety for the ultimate load transfer of 3. However, given the likelihood for fractured rock zones, we will target a larger factor of safety.

5) Check the required grout/steel bond strength.

Assumed grout compressive stress (fc) =	4000	psi	Assumed
Bond length =	10	ft	Calculated from Step 4.
Ultimate average bond force per in of length of bar =	2214	lbs/in	$U_n = 35\sqrt{f_c}$ ACI 318, Chapter 12
Ultimate average bond force across bond length =	265631	lbs	
	266	**kips**	
Applied Service Load =	25000	lbs	
Check Factor of Safety =	10.6		

Conclusion:

For dowels to resist an unfactored service of 25 kips (load per dowel), the following minimum requirements will need to be satisfied:

Minimum drill hole diameter =	4	inches
Mimimum Bar Requirement =	#8, 75ksi threadbar	
Mimimum Bar Area =	0.79	in2
Minimum Yield Strength (YS)=	59	kips
Minimum Grout Compressive Stress (fc)=	4000	psi
Minimum Bond Length =	10	feet

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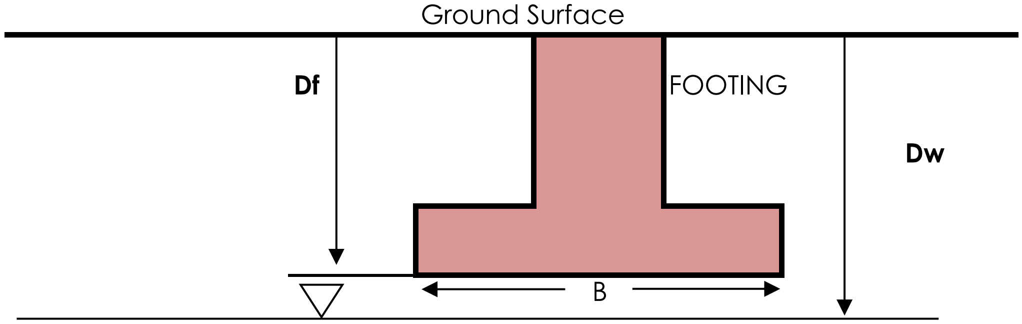
CALCULATIONS

Date:	11/8/2024	**Prepared by:**	CJVH
Project No.:	16667	**Reviewed by:**	CJS
Subject:	Bearing Capacity - Pipe Supports	**Checked by:**	MCP
Project Short Title:	Woodland Fish Passage Design		
Location:	Woodland, ME		



(1) Determine the effective stress at base of spread footing.

Neutral Stress = $Density\ of\ Water * Height\ of\ Water$

Neutral Stress = 0 lb/ft2

Effective Stress = $(Unsaturated\ Soil\ Depth * Dd) + (Bouyant\ Soil\ Depth * Db)$

Bouyant Soil Density (Db) = $Submerged\ Soil\ Density\ (Ds) - Density\ of\ Water$

Db = 57.6 lb/ft3
Effective Stress = 120 lb/ft3

(2) Determine the ultimate bearing capacity (Terzaghi).

Square Footing:

Qult = $(sc * c * Nc) + (sq * Cwq * q * Nq) + (0.5 * sg * Cwg * B * Ng * g)$

Cohesion	c =	0	lb/ft2 (0 for cohesionless soil)
	Nc =	42.2	dimensionless, from table
Effective Stress	q =	120	lb/ft2
	Nq =	29.4	dimensionless, from table
	Ng =	41.1	dimensionless, from table
Soil Density at Footing	g =	120	lb/ft3
Estimated Footing Width	Bs =	3	ft for square footing

(calculation continued)

Length of footing	Lf =	3	ft	
	sc =	1.25		1.70 use lesser of this number or 1.25
	sg =	0.6		0.6 use lesser of this number or 0.85
	sq =	1.00		1.67 conservatively use 1
	Cwg =	1.0		
	Cwq =	1.0		
	dq =	1	conservative	
	Qult =	7967	lb/ft2	
		3.98	tsf	
	Df=	1.0	ft	
	gbackfill	135.0	lb/ft3	
	Qnet =	7831.8	lb/ft2	
		3.92	tsf	
	Factor of Safety =	3		
	Allowable Bearing Capacity =	**1.3**	**tsf**	

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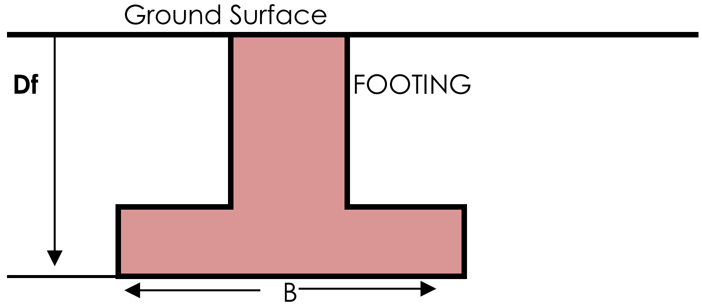
CALCULATIONS

Date:	11/8/2024	**Prepared by:**	CJVH
Project No.:	16667	**Reviewed by:**	CJS
Subject:	Immediate Cohesionless Settlement	**Checked by:**	MCP
Project Short Title:	Woodland Fish Passage Design		
Location:	Woodland, ME		



$$\Delta H = qB\frac{1-\mu^2}{E_s}I_w \tag{5-10}$$

where ΔH = settlement
q = intensity of contact pressure in units of E_s
B = least lateral dimension of footing in units of ΔH
I_w = influence factor which depends on shape of footing and its rigidity (typical values are given in Table 5-4)
E_s, μ = elastic properties of soil (typical values in Tables 2-6 and 2-7)

q =	2.6	in ksf (use recommended pressure from bearing capacity calc)
B =	36	assumed typical footing width in inches
I =	0.82	square, rigid footing, from attached Table 5-4
Es =	500	in ksf, from attached Table 2-6
μ =	0.25	dimensionless, from attached Table 2-7

ΔH = 0.144 inches

Include Factor of Safety of = 2

ΔH = 0.288 inches (total settlement)

Table 2-6 Typical range of values for the static stress-strain modulus E_s for selected soils
Field values depend on stress history, water content, density, etc.

Soil	E_s ksf	E_s Mpa
Clay		
Very soft	50–250	2–15
Soft	100–500	5–25
Medium	300–1000	15–50
Hard	1000–2000	50–100
Sandy	500–5000	25–250
Glacial till		
Loose	200–3200	10–153
Dense	3000–15 000	144–720
Very dense	10 000–30 000	478–1440
Loess	300–1200	14–57
Sand		
Silty	150–450	7–21
Loose	200–500	10–24
Dense	1000–1700	48–81
Sand and gravel		
Loose	1000–3000	48–144
Dense	2000–4000	96–192
Shale	3000–300 000	144–14 400
Silt	40–400	2–20

Table 5-4 Influence factors I_w, I_m for various-shaped members and for flexible and rigid footings

	Flexible			Rigid	
Shape	Center	Corner	Average	I_w	I_m*
Circle	1.00	0.64 (edge)	0.85	0.88†	6.0
Square	1.12	0.56	0.95	0.82	3.7
Rectangle:					
$L/B = 0.2$					2.29
0.5					3.33
1.5	1.36	0.68	1.15	1.06	4.12
2	1.53	0.77	1.30	1.20	4.38
5	2.10	1.05	1.83	1.70	4.82
10	2.54	1.27	2.25	2.10	4.93
100	4.01	2.00	3.69	3.40	5.06

* Lee (1962).

† Others have used the value $0.79 = \pi/4$ for the rigid-footing influence factor for circular footings.

Table 2-7 Typical range of values for Poisson's ratio μ

Type of soil	μ
Clay, saturated	0.4–0.5
Clay, unsaturated	0.1–0.3
Sandy clay	0.2–0.3
Silt	0.3–0.35
Sand (dense)	0.2–0.4
Coarse (void ratio = 0.4–0.7)	0.15
Fine-grained (void ratio = 0.4–0.7)	0.25
Rock	0.1–0.4 (depends somewhat on type of rock)
Loess	0.1–0.3
Ice	0.36
Concrete	0.15

verdantas **INSULATED FOUNDATIONS** **CALCULATIONS**

Date:	11/11/2024	**Prepared by:**	CJS	11/11/2024
Project No.:	16667	**Reviewed by:**	CJVH	11/13/2024
Subject:	Insulated Foundations	**Checked by:**	MCP	11/21/2024
Project Short Title:	Woodland Fish Passage Design			
Location:	Woodland, ME			

Purpose:

Design an insulated foundation frost protection alternative to full-depth excavation. Given the composition of fill materials and proximity to existing structures, full depth excavation and shoring is not anticipated to be practical.

References:

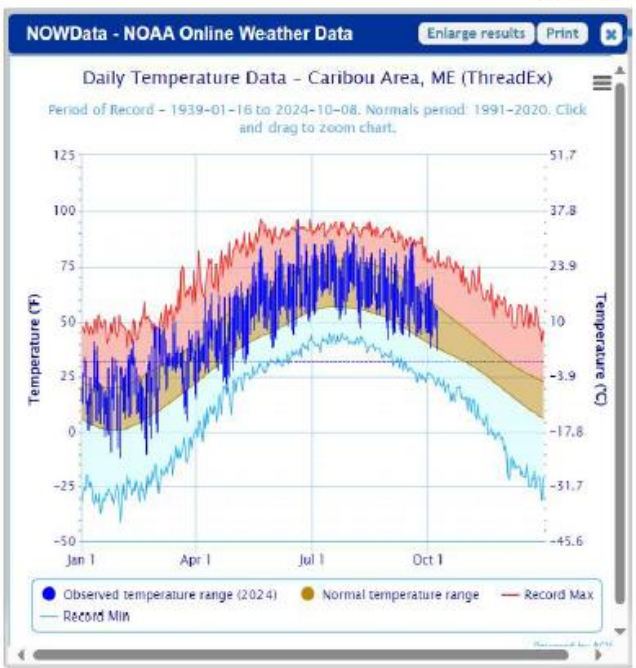
1. NOWData - NOAA Online Weather Data <https://www.weather.gov/wrh/Climate?wfo=car>
2. "Bridge Design Guide", 2003 with updates through 2018, Maine Department of Transportation.
3. Andersland, Orlando B., and Ladanyi, Branko (2004). "Frozen Ground Engineering", 2nd Ed., The American Society of Civil Engineers & John Wiley & Sons, Inc.

Discussion:

Andersland and Ladanyi (Reference 3) provide an approach for designing frost protection for foundations. This approach uses average annual temperatures and design freezing index to select the appropriate insulation and thickness of drainage material beneath the foundation. The following discussion outlines the assumptions and steps taken to determine the protection requirements. Supporting tables and figures are attached to the end of this package.

1. For the purposes of this evaluation, NOAA provides Climate Data Online for two ME locations Bangor and Caribou conservatively assume that Baileyville weather trends are the same as in Caribou. Based upon Reference 1, the annual mean temperature for Baileyville, ME is approximately 41°F or 5°C.

Step 1: References



NOWData - NOAA Online Weather Data

HDD (base 65)	41	50	74 in 1896	23 in 2022
CDD (base 65)	0	0	0 in 2023	0 in 2023
Month-to-Date Summary	**Observed**	**Normal**	**Record Highest**	**Record Lowest**
Avg Max Temperature	34.0	27.5	34.0 in 2023	13.2 in 1989
Avg Min Temperature	20.6	12.3	23.2 in 2015	-6.3 in 1989
Avg Temperature	27.3	19.9	28.5 in 2015	3.5 in 1989
Total Precipitation	3.47	3.60	7.97 in 1973	0.74 in 1963
Total Snowfall	9.9	25.2	59.9 in 1972	4.0 in 1982
Max Snow Depth	4	-	39 in 1978	3 in 2010
Total HDD (base 65)	1160	1398	1902 in 1989	1106 in 1939
Total CDD (base 65)	0	0	0 in 2023	0 in 2023
Year-to-Date Summary	**Observed**	**Normal**	**Record Highest**	**Record Lowest**
Avg Max Temperature	52.3	50.3	57.7 in 2024	46.2 in 1943
Avg Min Temperature	34.4	$\boxed{31.3}$	37.9 in 2024	26.2 in 1972
Avg Temperature	43.4	40.8	47.8 in 2024	36.2 in 1972
Total Precipitation	41.85	40.70	55.36 in 2011	26.69 in 1944
Total Snowfall (since July 1)	20.8	37.4	74.9 in 1972	0.0 in 2024
Max Snow Depth (since July 1)	4	-	39 in 1978	0 in 2024
Total HDD (since July 1)	2844	3389	4351 in 1976	322 in 2024
Total CDD (since Jan 1)	351	225	474 in 2020	52 in 1954

Compare to another year

Period of Record:

- Max Temperature : 1939-01-16 to 2024-10-08
- Min Temperature : 1939-01-16 to 2024-10-08
- Precipitation : 1939-01-16 to 2024-10-08
- Snowfall : 1939-06-01 to 2024-10-08
- Snow Depth : 1939-02-01 to 2024-10-08

2. Figure 5-1 (Reference 2), indicates the design freezing index for Baileyville falls between 1,600 and 1,700 degree-days F (22,700 degree-hours C). We conservatively assume the greater value of 1,700 degree-days F.

Step 2: References

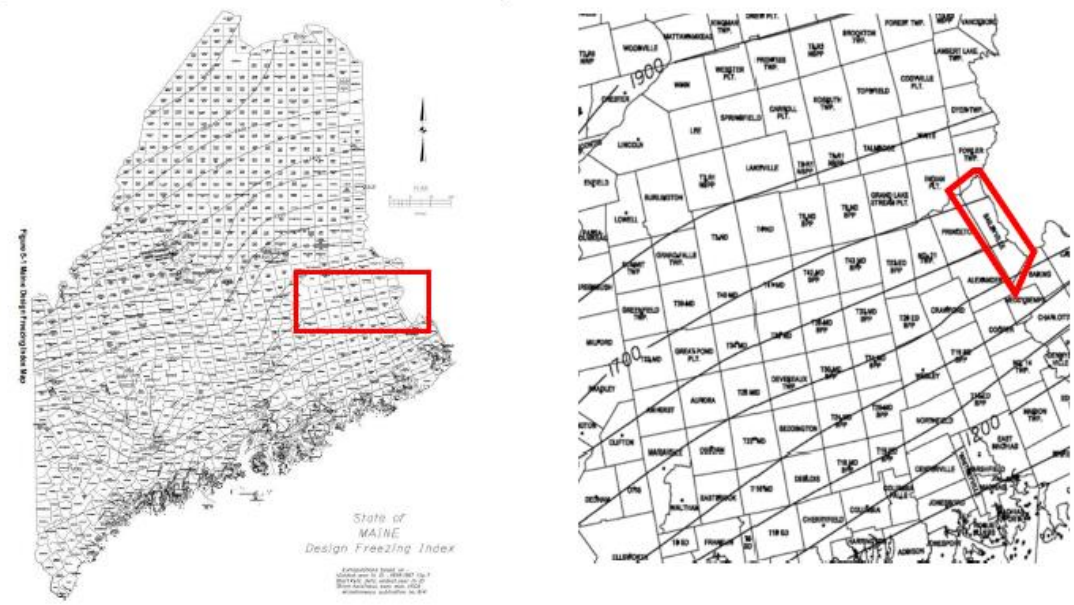


Figure 5-1 Maine Design Freezing Index Map

3. Table 7-8 (Reference 3), provides recommended drainage soil layer thickness below the foundation based on climate conditions and assuming insulation thickness of expanded polystyrene. Additionally, Table 7-9 (Reference 3), provides alternate insulation materials to expanded polystyrene and recommended correction factors and insulation thickness.

Assuming 50 mm (2 inches) of **expanded polystyrene** insulation, the climate conditions identified in steps 1 and 2, a minimum 0.31 meters (12.2 inches) of drainage material is required beneath the insulation. A recommended alternative insulation is extruded polystyrene insulation.

Extruded polystyrene is a alternative to expanded polystyrene. It requires no additional moisture protection and offers a slight reduction of required insulation thickness of a minimum of 43 mm (1.7 inches). To be conservative we recommend a thickness of 50 mm (2 inches) and not the correction factor for thickness.

Note: linear interpolation was used in step 2 to determine the required material thickness.

Step 3: References

TABLE 7-8 Frost Protection with Expanded Polystyrene and Underlying Drainage Material[a]

Design freezing index (°C)	Mean annual temp. (°C)	Necessary layer of drainage material (m) under expanded polystyrene insulation of the following thickness (mm)							
		0	40	50	60	80	100	120	150
≤3,000	1	0.6	0						
	3	0.5	0						
	5	0.4	0						
	7	0.4	0						
5,000	1	0.8	0						
	3	0.7	0						
	5	0.6	0						
	7	0.5	0						
10,000	1	1.2	0.1	0					
	3	1.1	0						
	5	0.9	0						
	7	0.8	0						
20,000	1	1.9	0.8	0.6	0.5	0.3	0.1	0	
	3	1.6	0.4	0.3	0.2	0			
	5	1.4	0.3	0.2	0.1	0			
	7	1.3	0.2	0.1	0				
30,000	1	2.3	1.2	1.1	0.9	0.7	0.4	0.3	0.1
	3	1.9	0.8	0.7	0.6	0.3	0.1	0	
	5	1.8	0.7	0.6	0.4	0.2	0		
	7	1.7	0.6	0.5	0.3	0.1	0		
40,000	1	2.6	1.5	1.3	1.2	0.9	0.7	0.5	0.4
	3	2.2	1.2	1.0	0.9	0.6	0.4	0.3	0.1
	5	2.1	1.1	0.9	0.8	0.5	0.3	0.2	0
50,000	1	2.8	1.7	1.5	1.4	1.1	0.9	0.7	0.6
	3	2.6	1.5	1.3	1.2	0.9	0.7	0.5	0.4

TABLE 7-9 Correction Factor for Insulation Thickness Given in Table 7-8 with the Use of Other Insulation Materials[a]

Insulation material	Insulation thickness in Table 7-8 multiplied by	Moisture protection
Extruded polystyrene	0.85	None
Expanded polystyrene		
Density of 20 kg/m³	1.4	Overlying plastic film
Density of 30 kg/m³	1.0 (basis)	Overlying plastic film
Mineral wool		
Density of 2,150 kg/m³	2.0	0.1-m thick drainage layer wrapped in plastic bag
Light aggregate	3.5	

Source: NBI 1987.

[a]The necessary moisture protection of the insulation is also shown.

4. Table 7-10 (Reference 3) provides recommended insulation length extending beyond the exterior perimeter of the footing. Based on the climate conditions identified Step 2, the insulation is required to extend a minimum 0.83 meters (33 inches) beyond the foundation.

Step 4: References

TABLE 7-10 Necessary Insulation Width Outside a Foundation Wall

Maximum freezing index (h · °C)	Insulation width (m)
10,000	0.50
20,000	0.75
30,000	1.00
40,000	1.25
50,000	1.50
60,000	1.50

Source: NBI 1987.

Conclusion:

Extruded polystyrene: The foundations will need a minimum 2 inch thick **extruded polystyrene** insulation that extends 3 feet beyond the exterior perimeter of the footing(s). The insulation should be underlain by a minimum 12 inch thick drainage layer. The schematic below shows a typical insulation.