Upper Red Rock Lake Arctic Grayling Winter Habitat Improvement Project

Project Manual

Technical Specifications

February 2022

Revision 0 – Issued for Bidding

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DIVISION 1
GENERAL REQUIREMENTS

SECTION 01010
SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. The Invitation to Bid contains a general description of the project work to be performed under this Contract. The Supplemental Conditions and Special Provisions and other documents contain additional information necessary to perform the work.

1.02 CONTRACT DOCUMENTS

A. The Invitation to Bid contains a general description of the project work to be performed under this Contract. The Supplemental Conditions and Special Provisions and other documents contain additional information necessary to perform the work.

B. The Contract Documents are intended to provide the basis for proper completion of the work suitable for the intended use of the Owner. Specifications and Drawings included in these contract documents establish the performance, quality requirements, location and general arrangement of materials and equipment, and establish the minimum standards for quality of workmanship and appearance. Anything not expressly set forth, but which is reasonably implied or necessary for proper performance of the project, shall be included.

C. The various portions of the Contract Documents, of which these specifications are a part, are essential parts of the Agreement, and a requirement occurring in any portion or part is binding as though occurring in all. All portions are intended to be complementary and to describe and provide for a complete work. Unless specifically noted otherwise, in the case of discrepancy, the following hierarchy shall be observed:

1. Addenda, which will govern over;
2. Special Provisions, which will govern over;
3. Standard Modifications, which will govern over;
4. Supplementary Specifications, which will govern over;
5. Project Drawings, which will govern over;
6. These Specifications and Standard Drawings, which will govern over;
7. Montana Department of Transportation Standard Specifications for Road and Bridge Construction

D. A requirement mentioned in one part/section of the Contract Documents shall be considered as having been mentioned in all parts/sections.

1.03 WORK SEQUENCE

A. Comply with the General Conditions and Milestones specified in the Contract Documents.

B. Submit detail schedules as specified in the Contract Documents.

C. Field verify dimensions indicated on drawings before fabricating or ordering materials. Do not scale drawings.

D. Notify Engineer/Owner of existing conditions differing from those indicated on the drawings. Comply of the General Conditions and any Supplementary Conditions of the Contract Documents. Verify the existence and location of underground utilities along the route of the proposed work. Omission of an existing or previous abandoned utility location on the Drawings is not to be considered as its nonexistence. Inclusion of existing utility locations on the Drawings is not to be considered as its definite location. Do not remove or alter existing utilities without prior written approval.

1.04 CONTRACTOR USE OF PREMISES

A. Comply with the requirements specified in the Contract Documents.

B. Do not park vehicles or equipment or store materials on private property without written permission from the property owner. Provide Engineer/Owner with copy of authorization.

1.05 OWNER-FURNISHED ITEMS

A. Owner-furnished items, if any, are listed in the Contract Documents or are summarized below.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT

A. Unless specifically noted otherwise, the work of Division 1 shall be incidental to the work, and no separate payment shall be made.

END OF SECTION

SECTION 01030
MOBILIZATION

PART 1 GENERAL

1.01 MOBILIZATION

A. Mobilization includes the resources needed to prepare for the start of work. Mobilization includes but is not limited to the following:

1. Moving personnel, equipment, supplies, and incidentals to the project site.
2. Other preparatory work and operations.
3. Permits and other incidentals related to the transport of equipment and supplies to the project site.

1.02 DEMOBILIZATION

A. Demobilization includes the resources required to prepare for completion of the work. Demobilization includes but is not limited to the following

1. Moving personnel, equipment, supplies, and incidentals from the project site.
2. Other preparatory work and operations.
3. Permits and other incidentals related to the transport of equipment and supplies from the project site.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 01041
PROJECT COORDINATION

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the requirements for coordinating and sequencing the work under the Contract documents, and requirements regarding existing site conditions.

1.02 COORDINATION WITH PUBLIC AND PRIVATE AGENCIES

A. Comply with the General Conditions of the Contract Documents. Permit utility companies to repair or replace their lines in the project limits.

B. Contact the Montana one-call system for utility locations before starting work.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 010500
FIELD ENGINEERING

PART 1 GENERAL

1.01 GENERAL

A. Do not begin work until the lines and grades that will control the work are staked. Preserve project control benchmarks, stakes, and marks placed by the Engineer.

1.02 ENGINEERING SURVEY

A. When the contract does not include Contractor Surveying as a pay item, the Engineer will set construction stakes establishing lines, slopes, profile grades, centerline, and bench marks. Use the engineer's stakes and marks to establish extended control. To avoid delays, notify the Engineer at least ten (10) calendar days before starting work that requires staking.

1.03 CONTRACTOR SURVEYING

A. When Contractor Surveying is a pay item, the Contractor is responsible for grade staking the project. Perform survey work under the supervision of a qualified individual with knowledge and experience in construction surveys.

B. The Engineer will establish horizontal and vertical control for the project. The Engineer will furnish necessary information relating to lines, slopes, and grades. Use these stakes and/or information as the field control to establish the project benchmarks and to perform the work.

C. Keep survey notes in a clear, orderly, neat manner. Ensure survey records are available to the Engineer for inspection or reproduction at all times. Correct deficiencies and transmit survey records to the engineer for inclusion in the project records before final project acceptance.

D. Upon discovery, notify the engineer of apparent errors in or discrepancies with previous surveys. Obtain corrections or interpretations before proceeding.

E. Correct deficient work due to incorrect staking or failure to report errors or inaccuracies in work previously performed. Reset grade stakes, benchmarks, reference points, or property corners lost, damaged, or destroyed by traffic or construction.

1.04 MACHINE CONTROLS

A. GENERAL
Machine controls include any equipment properly equipped to establish the lines and grades of the project without the use of construction staking.

B. If the Contractor elects, or Machine Controls are specified, to use machine controls to establish the lines and grades of the project, the Engineer shall make available to the Contractor digital terrain files (DTMs) for use by the Contractor.

C. Any manipulation of DTM electronic files (files) supplied by the Engineer to the Contractor by the Contractor, or any third-party providing machine control services to the Contractor, shall not be allowed unless authorized by the Engineer.

D. Should the Contractor require manipulation of DTM files for compatibility with machine controls, the Contractor shall coordinate with the Engineer in accordance with Section 01041 - Project Coordination to ensure manipulated DTMs are in accordance with the design information presented by the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide personnel, materials, and equipment necessary to perform the work. Calibrate equipment before starting, and submit calibration data, information from field checks of the calibration, and results including location and dates performed, to the Engineer.

B. Provide wooden lathe with dimensions of ¾”x1-1/2”x48” and wooden hub stakes with dimensions of 1”x1”x6”, minimum.

PART 3 EXECUTION

3.01 GRADE STAKING

A. Set grade stakes required to control the work. Establish the grade stake elevation for the subgrade using grade information provided by the Engineer.

B. Set reference points and reference lines to control alignment and the grade elevations at the subgrade. Establish additional lines as required for offsets, berms-in-fill, and profile grade-breaks.

C. Set reference points and lines to produce the typical sections specified.

D. Set subgrade grade stakes for tangent sections at intervals no greater than 100 ft., no greater than 50 ft. for curves, and at other miscellaneous break points as specified.

END OF SECTION

SECTION 01090
REFERENCES

PART 1 GENERAL

1.01 COORDINATION OF CONTRACT DOCUMENTS

1.02 REFERENCES

A. This section lists some of the construction industry organizations, professional and technical associations, societies and institutes, and government agencies issuing, promoting, or enforcing standards in the Contract Documents along with the abbreviations commonly used for those references. Also included are general requirements for using industry standards specified, and for applying quality control standards.

1.03 USE OF REFERNCE STANDARDS

A. Work specified by reference to a published standard or specification of a government agency, technical association, trade association, professional society or institute, testing agency, or other organization must meet or exceed the minimum quality standards for the material and workmanship in the designated standard or specification.

B. Where specified, assure products or workmanship meet the prescriptive or performance requirements in the Contract Documents when it is a more stringent standard than the referenced standard. Contract should reference only one specification to prevent argument as to which specification is most stringent.

C. Where the specific issue date of the standard is not identified in the standard, the edition and all published amendments available on the date of the Invitation to Bid applies.

D. If two or more standards are specified, provide the product and workmanship meeting or exceeding the requirements of the most stringent standard.

E. If a conflict exists between standards, meet the more stringent standard.

F. Where both a standard and a brand name are specified, assure the proprietary product names meet or exceed the specified reference standard. The listing of a trade name in a Contract Document does not warrant that the product meets the referenced standard.

G. Copies of Standards

1. Copies of applicable referenced standards are not bound in this Contract Document.
2. Where the contractor needs copies of standards for work superintendence and quality control, obtain a copy or copies directly from the publication sources and maintain copies at the job site, making them available to Contractor personnel, subcontractors, Owner, and Engineer.

1.04 ABBREVIATIONS

A. Abbreviations for Trade Organizations and Government Agencies: Following is a list of construction industry organizations and government agencies commonly referenced in the Contract Documents, with abbreviations used.

AA	Aluminum Association
AAMA	Architectural Aluminum Manufacturers' Association AASHTO American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AFBMA	Anti-Friction Bearing Manufacturers' Association AGA American Gas Association
AGMA	American Gear Manufacturers' Association AISC American Institute of Steel Construction AISI American Iron and Steel Institute
AITC	American Institute of Timber Construction ALS American Lumber Standards
AMCA	Air Moving and Conditioning Association ANSI American National Standards Institute APA American Plywood Association
API	American Petroleum Institute
AREA	American Railway Engineering Association ARI Air Conditioning and Refrigeration Institute
ASAE	American Society of Agricultural Engineers ASCE American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers ASSE American Society of Sanitary Engineers ASTM American Society for Testing and Materials AWI Architectural Woodwork Institute
AWPA	American Wood Preservers' Association AWPB American Wood Preservers' Bureau AWPI American Wood Preservers' Institute AWS American Welding Society
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers' Association CBMA Certified Ballast Manufacturers' Association CDA Copper Development Association
CGA	Compressed Gas Association
CISPI	Cast Iron Soil Pipe Institute
CMAA	Crane Manufacturers' Association of America CRSI Concrete Reinforcing Steel Institute
FGMA	Flat Glass Marketing Association FM Factory Mutual
Fed Spec.	Federal Specifications FS Federal Specification

GA	Gypsum Association
HI	Hydraulic Institute
HMI	Hoist Manufacturers' Institute
ICBO	International Conference of Building Officials ICEA Insulated Cable Engineers' Association
IEEE	Institute of Electrical and Electronics Engineers, Inc. IES Illuminating Engineering Society of North America ISA Instrument Society of America
JIC	Joint Industry Conferences of Hydraulic Manufacturers MIA Marble Institute of America
Mil. Sp.	Military Specification MS Military Specifications
MMA	Monorail Manufacturers' Association
NAAMM	National Association of Architectural Metal Manufacturers NBHA National Builders' Hardware Association
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association NESC National Electrical Safety Code
NFPA	National Fire Protection Association
NHLA	National Hardwood Lumber Association
NLMA	National Lumber Manufacturers' Association
NTMA	National Terrazzo and Mosaic Association NWMA National Woodwork Manufacturers' Association OECI Overhead Electrical Crane Institute
OSHA	Occupational Safety and Health Act (both Federal and State) PEI Porcelain Enamel Institute
PS	Product Standards Section - U.S. Department of Commerce RLM RLM Standards Institute, Inc.
RMA	Rubber Manufacturers' Association SAE Society of Automotive Engineers
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturing Association SJI Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Steel Structures Painting Council SWI Steel Window Institute
TEMA	Tubular Exchanger Manufacturers' Association TCA Tile Council of America
UBC	Uniform Building Code
UFC	Uniform Fire Code
UL	Underwriters' Laboratories, Inc. WCLIB West Coast Lumber Inspection Bureau WWPA Western Wood Products Association
NLMA	National Lumber Manufacturers' Association NTMA

	National Terrazzo and Mosaic Association NWMA
	National Woodwork Manufacturers' Association OECI
	Overhead Electrical Crane Institute
OSHA	Occupational Safety and Health Act (both Federal and State) PEI
	Porcelain Enamel Institute
PS	Product Standards Section - U.S. Department of Commerce RLM
	RLM Standards Institute, Inc.
RMA	Rubber Manufacturers' Association SAE
	Society of Automotive Engineers
SDI	Steel Deck Institute
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturing Association SJI
	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National
	Association
SSPC	Steel Structures Painting Council SWI
	Steel Window Institute
TEMA	Tubular Exchanger Manufacturers' Association TCA
	Tile Council of America
UBC	Uniform Building Code
UFC	Uniform Fire Code
UL	Underwriters' Laboratories, Inc. WCLIB
	West Coast Lumber Inspection Bureau WWPA
	Western Wood Products Association

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 01300
SUBMITTALS

PART 1 GENERAL

1.01 CONSTRUCTION SCHEDULES

A. Submit to the Engineer a progress schedule under Sections 2.03, 2.05 and 4.04 of the General Conditions.

B. Submit to the Engineer adjusted progress schedules under Section 4.04 of the General Conditions.

C. Submit to the Engineer, value schedules under Sections 2.03 and 2.05 of the General Conditions.

1.02 SHOP DRAWINGS, PRODUCT DATE, AND SAMPLES:

A. Submit shop drawings to the Engineer under Sections 2.03, 2.05 and 7.16 of the General Conditions. Submit all shop drawings for the Contractor, subcontractor(s), and supplier(s)

B. Review all shop drawings prior to submittal in accordance with Section 7.16 of the General Conditions.

C. Submit in writing any substitutions to previously approved items for review by the Engineer.

D. Within 15 days after Notice to Proceed, submit a complete list of products proposed for use, providing manufacturer's name, trade name, and model or catalog numbers, and manufacturer data. Submit the number of copies needed by the Contractor, plus three copies for Engineer use.

E. Where specified, submit samples to illustrate functional and aesthetic characteristics of the Product, with integral parts and attachment devices. Where specified, submit samples of finishes including colors, textures, and patterns.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 01400
CONTRACTOR QUALITY CONTROL AND OWNER QUALITY ASSURANCE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the Contractor quality control testing requirements and Owner's quality assurance program.

1.02 REFERENCES

A. American Society of Testing Materials (ASTM)

1. ASTM E 329 Evaluation of Testing and Inspection Agencies as Used in Construction

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 GENERAL

A. Be responsible for quality control tests and inspections to control contractor production and construction processes. Include in the Contractor quality control system an internal organization, plans, and procedures to produce the specified end product. Assure the system covers all construction operations, both on-site and off-site, and is keyed to the construction sequence. Quality control testing frequency is at Contractor discretion, except where tests are specifically required in the technical specifications for individual products.

B. Sampling and testing to assure specification conformance are performed by the Owner or the Owner's testing agency as quality assurance testing.

C. The Owner may select a testing agency to perform quality assurance testing. (ASTM E329 is referenced as a guide to the selection of a qualified testing agency.) The Owner will pay for (or provide) the quality assurance testing. Quality assurance testing frequency is at Owner discretion for individual products.

D. Quality assurance testing is performed following the standards in the technical specifications for individual products.

3.02 CONTRACTOR COOPERATION WITH QUALITY ASSURANCE AGENCY

A. Assure the Owner's personnel and quality assurance agency have access to all work areas at all times work is in progress. Provide any special facilities or equipment to access work areas at Contractor expense.

B. Notify the Engineer of the work ready for quality assurance testing. Establish and update as the construction schedule to provide the Engineer estimated sampling/testing dates and times.

END OF SECTION

SECTION 01530
SECURITY

PART 1 GENERAL

1.01 SUMMARY

A. Protect the site, materials, and operations from theft, vandalism, and unauthorized entry.

B. Initiate security measures in coordination with the Owner's existing program at project site. Maintain the security measures throughout the construction period until the Owner's acceptance.

PART 2 PRODUCTS

2.01 BARRIERS

A. Provide earthen or other barriers around excavation sufficient to protect against vehicle or unauthorized personnel entry.

PART 3 EXECUTION

3.01 ENTRY CONTROL

A. GENERAL

1. Restrict entrance of persons and vehicles on to the project site and existing facilities. Restricted existing facilities are designated and may be modified or changed by the Owner. Only authorized individuals with proper identification will be allowed access.
    a. Maintain log of workers and visitors entering the project site. Make this log available to the Owner upon request.
    b. Contractor shall not be allowed to enter established or designated restricted areas unless authorized by Owner. Contractor is responsible for ensuring the Contractor's personnel or those under the direct responsibility of the Contractor shall not enter these areas.

END OF SECTION

SECTION 01540
TEMPORARY FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Furnish temporary services and utilities, including use fees and operation costs for:

1. Potable and non-potable water;
2. Lighting and power; and
3. Materials storage

B. Furnish construction facilities, including utility costs for:

1. Construction equipment; and
2. Dewatering and pumping, if required

C. Furnish security and protection requirements for:

1. Fire extinguishers;
2. Site enclosure fence, barricades, warning signs, and lights; and
3. Snow and ice removal, if applicable

D. Furnish personnel support facilities for:

1. Sanitary facilities;
2. Drinking water;
3. First aid facilities;
4. Coordinate emergency medical services;
5. Trash removal;
6. Field office; and
7. Lay down and staging area

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 01570
CONSTRUCTION TRAFFIC CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the requirements for furnishing, placing, operating, maintaining, repairing, and removing temporary traffic control devices to ensure the safety of the general public and project personnel.

1.02 REQUIREMENTS

A. Perform work under this section meeting Manual of Uniform Traffic Control Services (MUTCD) and contract requirements.

1.03 NOTIFICATIONS

A. Coordinate all construction activities to reduce traffic conflicts at the work site, off-site events, or other construction projects.

B. Furnish, for Owner review, the construction traffic control plan at least one week before construction begins or before changes in segments or phases of the work on the project. The Owner will review and approve the Traffic Control Plan considering known off-site activities and may require modification to the plan or construction timing to coordinate events. Work shall not commence until said plan is approved.

C. For project sites involving a through street, provide the Engineer with a news release. Include in the news release, as a minimum, the work activity and duration. Once approved, furnish the news release to the local media at least three days before starting work. Notify all landowners or residents adjacent to the work of the type and duration of the construction.

PART 2 PRODUCTS

2.01 TRAFFIC CONTROL DEVICES

A. Assure all signs and barricades are reflectorized. Assure all nighttime traffic control devices meet MUTCD lighting requirements.

B. Use traffic control devices meeting the “Manual of Uniform Traffic Control Devices” and the “Traffic Control Devices Handbook” requirements, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20492.

C. Assure all traffic control devices are clean, legible, reflective for night-time use, and operable.

PART 3 EXECUTION

3.01 WORK METHODS

A. Place all traffic control devices as planned before permitting men or equipment on the traveled way. Install signs, cones and barricades in that order.

B. Inspect the work area at least twice each day during construction and maintain records of traffic control devices used and their location.

C. Assure traffic control is appropriate to the work. Assure traffic control devices are appropriate and clean before suspending work for the day.

D. Remove traffic control devices in reverse order of installation at the end of each shift.

E. Remove and store all unnecessary traffic control devices away from traffic's view., install, locate, maintain, and remove construction traffic control devices.

F. If changes to the traffic control plan are proposed, prepare a revised traffic control plan, and submit it to the engineer at the preconstruction conference. Do not change traffic operations from the details and standard plans included in the contract, unless an alternate plan is submitted to and approved in writing by the Owner. Ensure the alternate plan is the same quality and detail as the one shown in the contract. Modify the plan as the situation warrants and submit the revised plan to the Owner for approval.

3.02 NONCOMPLIANCE

A. Remove, repair or replace any traffic control device not providing its intended function.

B. Do not begin work until all required traffic control devices are placed.

C. The Engineer will periodically inspect the traffic control and inform the Contractor of any deficiencies.

D. Contractor failure to correct any deficiency in the traffic control within 4 hours of notification is cause to deduct monies from the contract payment on the next progress payment.

E. The Engineer may direct correcting traffic control deficiencies immediately. Failure to immediately correct the deficiency is cause for the Engineer to correct the deficiency at Contractor expense.

3.03 FLAGGING

A. Furnish competent and properly equipped flag persons as described in the booklet "Instructions for Flag persons" furnished by the Montana Department of Transportation.

END OF SECTION

SECTION 01700
CONTRACT CLOSEOUT

PART 1 GENERAL

1.01 CLEANUP

A. Before Final inspection (as outlined in Section 14.06 of the General Conditions) execute the following.

1. Where applicable, clean interior and exterior glass and surfaces exposed to view. Remove temporary labels.
2. Where applicable, clean equipment and fixtures to a sanitary condition.
3. Where applicable, clean debris from roof, gutters, and downspouts.
4. Remove debris, waste, surplus materials, and rubbish from right-of-way, easements (construction or permanent) and private property.
5. Where applicable, remove debris, dirt, and silt from storm drain basins, sanitary sewer and storm drain manholes, and water valve boxes.
6. Rake landscaped surfaces clean of debris.
7. Where applicable, remove temporary coverings from traffic control devices.
8. Clean traffic control devices and signs.
9. Where applicable, remove temporary traffic striping.
10. Sweep dirt and debris from all paved areas affected by the work.

1.02 RECORD DOCUMENTS

A. Submit record documents as outlined in the General Conditions. Final payment will not be processed until the documents are submitted to and approved by the Engineer.

1.03 OPERATION AND MAINTENANCE DATA

A. Where applicable, submit two sets, before final inspection, bound in three ring binders. Prepare a table of contents for each volume with each product or system identified.

B. Where applicable, prepare the following:

1. Directory, listing names, addresses and telephone numbers of Engineer, Contractor, Subcontractor, and Equipment Suppliers.
2. Operations and maintenance instructions, arranged by system. For each category, identify the applicable Contractor(s) or Subcontractor(s) and suppliers. Identify the following:
    a. Significant design criteria
    b. List of equipment
    c. Parts list for each component

d. Operating instructions

e. Maintenance instructions

1.04 WARRANTIES AND BONDS

A. Submit, with final payment request, all warranty certificates, lien releases, and consent of security forms.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION

DIVISION 2

SITEWORK

SECTION 02105
SITE PREPARATION

PART 1 GENERAL

1.01 SUMMARY

A. Work in this section includes furnishing all labor, materials, equipment and services required for clearing and grubbing, removal, and disposal of items as specified herein and on the plans.

1.02 REFERENCES

A. Section 02106 - Clearing and Grubbing

B. Section 02205 - Earthwork and Grading

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 CLEARING AND GRUBBING

A. Clearing and grubbing shall consist of removing all natural and artificial objectionable materials from the project site or from limited areas of construction as per Section 02106 - Clearing and Grubbing.

3.02 MINOR DEMOLITION

A. There may be certain items on the site such as old building foundations, fences, and other undetermined structures and improvements that must be removed before construction can commence. Unless otherwise specified, such items become the property of the Contractor for subsequent disposal.

3.03 USE OF EXPLOSIVES

A. The use of explosives will not be permitted in site preparation operations.

3.04 BACKFILLING

All holes, cavities, and depressions in the ground caused by site preparation operations will be backfilled, compacted, and graded to prevent ponding of water and to promote drainage. Should any excavated hole or cavity be required to be left open, the Contractor shall be responsible to provide barriers and / or coverings to enhance on site accident prevention measures.

3.05 DISPOSAL OF WASTE MATERIALS

A. Unless otherwise stated, materials generated by clearing, grubbing, removal, and demolition shall be known as "waste" or "spoils" and shall be removed from the site and disposed of by the Contractor. Similar materials may be unearthed or generated by earthwork operations or by subgrade preparation. Unless otherwise specified any merchantable items become the property of the Contractor.

END OF SECTION

SECTION 02106
CLEARING AND GRUBBING

PART 1 GENERAL

1.01 SUMMARY

A. This work shall consist of clearing, grubbing, removing, and disposing of all vegetation and debris within the limits of the construction area. Vegetation and objects designated to remain shall be preserved from injury or defacement.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

A. Unless otherwise established by the Engineer, all areas between the neat lines of cut or fill areas shall constitute the clearing and grubbing limits. The clearing limits shall be two (2) feet within the neat lines of cut or fill areas.

B. All stumps, roots, logs, brush, matted roots, and other debris within the grubbing limits shall be pulled or otherwise removed to a depth of not less than 6 inches below the original ground or twelve (12) inches below subgrade.

C. The refuse resulting from the clearing and grubbing operation may be hauled to an available waste site approved by the OWNER and shall be disposed of in such a manner as to meet all requirements of State, county, municipal, or OWNER regulations regarding health, safety, and public welfare. When authorized by the proper fire authorities, the Contractor may dispose of such refuse by burning on the site of the project provided all requirements set forth by the authorities are met.

D. In all cases, the authority to burn shall not relieve the Contractor in any way from damages which may result from his operations. In no case shall any material be left on the project, shoved onto abutting private properties, or be buried in embankments or trenches on the project.

E. The Contractor shall avoid, as far as practicable, injury to shrubbery, vines, plants, grasses and other vegetation growing on areas outside of the grading area.

END OF SECTION

SECTION 021100
GEOTEXTILES

PART 1 GENERAL

1.01 DESCRIPTION

A. This work consists of furnishing, and placing a geotextile as a subsurface drainage fabric permeable separator between dissimilar materials (such as between subgrade and sub base/base), stabilization fabric, temporary and/or permanent erosion control measures or as waterproofing/stress releasing membrane within pavement structures.

1.02 REFERENCES

A. The current publications listed below form part of this specification.

B. ASTM Standards

1. D123 Standard Terminology Relating to Textiles
2. D276 Test Methods for Identification of Fibers in Textiles
3. D4354 Practice for Sampling of Geosynthetics for Testing
4. D4632 Breaking; Load and Elongation of Geotextiles (Grab Method)
5. D4533 Trapezoid Tearing, Strength of Geotextiles
6. D3786 Hydraulic Bursting, Strength of Knitted Goods and Nonwoven Fabrics Diaphragm Bursting Strength Tester Methods
7. D4833 Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
8. D4491 Water Permeability of Geotextiles by Permittivity
9. D4751 Determining, Apparent Opening, Size of a Geotextile
10. D4354 Sampling, of Geotextiles for Testing
11. D4759 Determining, the Specification Conformance of Geosynthetics
12. D276 Identification of Fibers in Textiles
13. D4355Deterioration of Geotextiles from exposure to ultraviolet light & water (Xenon-arc type apparatus)
14. D4873Guide for Identification, Storage and Handling of Geotextiles
15. D5141 Test Method for Determining Filter Efficiencyand Flow rate for Silt Fence Application of a Geotextile Using Site Specific Soils
16. D5261 Test Methods for Measuring Mass per Unit Area of Geotextiles
17. D422 & D1140 Particle Size Analysis of Soils
18. D4318 Determining the Plastic Limit and Plasticity Index of Soils

19. D698 The Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) drop

C. ASSHTO Specifications – M288 Geotextile Specifications for Highway Applications

1. Augmenting and prevailing over this specification section.

1.03 SUBMITTALS

A. Submit all product data sheets to the Engineer for review and approval prior-to procurement of geotextile materials.

PART 2 PRODUCTS

2.01 PHYSICAL AND CHEMICAL REQUIREMENTS

A. Assure that fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, consist of long-chain synthetic polymers, composed of at least 95% by weight polyolefins or polyesters. They must be formed into a network so the filaments on yarns retain dimensional stability relative to each other, including selvedges. Furnish materials meeting the physical requirements for the indicated application as described by the corresponding table(s) of properties in ASSHTO M288, Geotextile Specifications for Highway Applications.

2.02 CERTIFICATION

A. Assure the manufacturer furnishes the purchaser a certificate stating: the name of the manufacturer, the chemical composition of the filaments or yarns, and other information fully describing the geotextile. The manufacturer must include in the certificate, a guarantee stating that the geotextile furnished meets specifications. The certificate must be attested to by a person having a legal authority to bind the company. Mismarking, or misrepresentation by the manufacturer is reason to reject the geotextile under these specifications. Notice sent to the manufacturer by the purchaser regarding rejection of, will be considered to be notice to all wholesalers, jobbers, distributors, agents and other intermediaries handling the manufacturer's product.

B. Label the fabric and its container with the manufacturer's name and fabric type or trade name, lot number and quantity.

2.03 SHIPMENT AND STORAGE

A. During shipment and storage, protect the fabric from direct sunlight, ultra-violet rays, temperatures exceeding 160^0F (71^oC), mud, dust and debris. Keep the fabrics in the manufacturer's wrapping until just before use. Include with each shipping, a document, a certification showing that the geotextile meets the manufacturer’s certificate and a guarantee that has been previously filed with the purchaser.

PART 3 EXECUTION

3.01 GENERAL

A. Where placing geotextiles on native ground, cut the trees and shrubs flush with the ground surface. Do not remove the topsoil and vegetation mat. Remove all sharp objects and large rocks. Fill depressions or holes with a suitable material to provide a firm foundation.

B. Replace or repair all geotextile that is torn, punctured, or muddy. Remove the damaged area and place a patch of the same type of geotextile overlapping 3 feet, in all directions, (0.9m) beyond the damaged area.

3.02 DRAINAGE, SEPERATION AND STABILIZATION APPLICATIONS

A. Shape the subgrade to a smooth surface and to the cross section required. Shape slopes to gradually transition into slope adjustments without noticeable breaks. At the ends of cuts, the intersection of cuts, and embankments, adjust slopes in the horizontal and vertical planes to blend into each other or into the natural ground.

B. Remove all material larger than 6 inches (15 cm) within the top 6 inches (15 cm) of the roadbed. Remove unsuitable material from the roadbed and replace with suitable material. Finish the roadbed and ditches to the required elevation and cross-section.

C. Place the geotextile smooth and free of tension, stress, or wrinkles. Fold and cut the geotextile to conform to curves. Overlap in the direction of construction. Overlap the geotextile a minimum of 2 feet (0.6m) at the ends and sides of adjoining sheets or sew the geotextile joints according to the manufacturer's recommendations. Do not place longitudinal overlaps below anticipated wheel loads. Hold the geotextile in place with pins, staples, or piles of cover material.

D. End dump the cover material onto the geotextile from the edge of the geotextile or from previously placed cover material. Do not operate equipment directly on the geotextile. Spread the end-dumped pile of cover material maintaining a minimum lift thickness of 10 inches (250mm). Compact the cover material with rubber- tired or nonvibratory smooth drum rollers. Avoid sudden stops, starts, or turns of the construction equipment. Fill all ruts from construction equipment with additional cover material. Do not regrade ruts with placement equipment.

E. Place subsequent lifts of cover material in the same manner as the initial lift. Vibratory compactors may be used for compacting subsequent lifts. If foundation failures occur, repair the damaged areas and revert to the use of nonvibratory compaction equipment.

3.03 TEMPORARY AND PERMANENT EROSION CONTROL APPLICATIONS

A. Place and anchor the geotextile on the approved smooth-graded surface. For slope protection, place the long dimension of the geotextile down the slope. For stream bank protection, place the long dimension of the geotextile parallel to the centerline of the channel.

B. Overlap the geotextile a minimum of 12 inches (300mm) at the ends and sides of adjoining sheets or sew the geotextile joints according to the manufacturer's recommendations. Overlap the uphill or upstream sheet over the downhill or downstream sheet. Offset end joints of adjacent sheets a minimum of 5 feet (1.5m). Pins may be used to hold the geotextile sheets in place. Space pins along the overlaps at approximately 3 foot (1m) centers.

C. Place aggregate, slope protection, or riprap on the geotextile starting at the toe of the slope and proceed upward. Place riprap onto the geotextile from a height of less than 12 inches (300 mm). Place slope protection rock or aggregate backfill onto the geotextile from a height less than 3 feet (0.9m). In underwater applications, place the geotextile and cover material in the same day.

3.04 PAVEMENT APPLICATIONS

A. Use SS-1 crack filler meeting the applicable section for crack filler for surface preparation of cracks between 1/8-and 1/4-inch wide. Fill cracks exceeding 1/4- inch (6 mm) width with an asphalt emulsion slurry consisting of 20 percent by volume of SS-1, 2 percent by volume Portland cement and the remaining portion fine sand.

B. Use distributors for spraying a Performance Graded (PG) Asphaltic Binder meeting the specifications for the asphalt cement being used in the asphalt concrete overlay.

C. Place fabric using manufacturer recommended equipment.

D. Handle and place all fabric following the manufacturer's recommendations.

E. Clean pavement to receive fabric of dirt, water and vegetation. Clean all cracks between 1/8-inch (3 mm) and 1/4-inch (6 mm) wide and fill flush to the surface with SS-1 bituminous material. Top with sand. Repair larger cracks or holes using the asphalt emulsion slurry. Pour the mixture into the cracks until full. Re- fill with slurry, the following day, any cracks which are not completely filled initially. When a leveling course is required, place it before installing the fabric. Areas to be covered with a leveling course do not require surface preparations for cracks unless the leveling courses will be less than 0.3 foot (10cm).

F. Uniformly apply the asphaltic binder at the rate determined by the Engineer. The quantity will vary with pavement porosity. Take care to place sufficient binder to satisfy the fabric and make the membrane impervious to water without causing a slippage plane. The applications rates are typically 0.25 to 0.30 gallon per square yard. Apply binder using a distributor.

G. Heat the asphalt binder high enough to permit a uniform spray pattern. Ensure air temperature is at least 50^0 F and rising before applying binder and fabric.

H. Place the paving geotextile onto the asphalt sealant with minimal wrinkling. Slit, lay flat and tack all wrinkles or folds higher than 1inch (25 mm). Broom and/or roll the paving geotextile to maximize fabric contact with the pavement surface.

I. At geotextile joints, overlap the geotextile 1 to 3 inches (25 to 75 mm) to ensure full closure. Overlap transverse joints in the direction of paving to prevent edge pickup by the paver. Apply additional asphalt sealant to paving geotextile overlaps to ensure proper bonding of the double fabric layer.

J. If asphalt sealant bleeds through the fabric, treat the affected areas with blotter. Minimize traffic on the geotextile. If circumstances require traffic on the fabric, apply blotter and place "slippery when wet" signs.

K. Broom the excess blotter from the geotextile surfaces before placing the overlay. Repair all damaged fabric before placing overlay. Apply a light tack coat before placing the overlay. To avoid damaging the geotextile, do not turn equipment on the geotextile.

L. Place a hot asphalt concrete overlay within 48 hours after placing the paving geotextile. Limit the lay-down temperature of the mix to a maximum of 325^0F (163^0C) except when the paving geotextile is composed of polypropylene fibers, limit the lay-down temperature of the mix to a maximum of 300^0F (149^0C).

END OF SECTION

SECTION 02221
TRENCH EXCAVATION AND BACKFILL FOR PIPELINES & APPURTENANT STRUCTURES

PART 1 GENERAL

1.01 DESCRIPTION

A. This work is the excavation, trenching and backfilling for pipelines and appurtenances. It includes all clearing, grubbing, site preparation, removal and disposal of debris from the excavation, handling and storing materials for fill and backfill, all bracing, shoring and trench protection, construction dewatering, all backfill, subgrade preparation , final grading, site dressing and cleanup.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)

1. AASHTO T11 Materials Finer Than 0.075mm (No. 200) Sieve in Mineral Aggregates by Washing (ASTM C117)
2. AASHTO T27 Sieve Analysis of Fine and Coarse Aggregate (ASTM C136)
3. AASHTO T89 Determining the Liquid Limit of Soils
4. AASHTO T90 Determining the Plastic Limit and Plasticity Index of Soils
5. AASHTO T99 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5-lb (2.5kg) Rammer and 12-inch (305mm) Drop
6. AASHTO T191 Density of Soil In-Place by the Sand-Cone Method (ASTM D1556)
7. AASHTO T310 In-Place density and water content of the soil and soil aggregate by Nuclear Method (Shallow Depth) (ASTM D6938)

B. American Society of Testing Materials (ASTM)

1. ASTM D698 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5-lb (2.5kg) Rammer and 12-inch (305mm) Drop
2. ASTM D4318 Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils

1.03 STANDARD DRAWINGS

A. Standard Drawings applicable to this section are as follows:

1. Standard Drawing No. 02221-1 - Typical Utility Trench Detail

1.04 TESTING

A. Field Density Testing

1. Meet the quality control and quality assurance testing requirements in Section 01400, Contractor Quality Control and Owner Quality Assurance.

2. In-place field density tests for quality assurance are at Owner expense meeting AASHTO T191 (ASTM D1556), Sand Cone Method; or by AASHTO T310 (ASTM D6938) Nuclear Densometer Methods. Quality assurance field density testing frequency is at the Engineer's discretion.
3. Re-testing failing areas is at the expense of the Contractor.
4. At the direction of the Engineer, provide necessary equipment and labor to excavate and replace materials for test holes up to 5 feet deep into the compacted backfill to allow testing below the surface of any layers covered without inspection and approval by the Engineer.

B. Laboratory Maximum Density and Optimum Moisture

1. Quality assurance tests will be made by the Engineer for each on-site natural soil or each source of off-site material, including borrow material, to determine the laboratory maximum density values and optimum compaction moisture content according to AASHTO T-99 or ASTM D698.

C. Material Submittals

1. Submit to the Engineer material quality test results including Type 1 Bedding gradation and plasticity index; and Type 2 Bedding gradation.
2. Submit to the Engineer samples of on-site and off-site borrow soils for laboratory moisture-density relationship testing by the Engineer.
3. If applicable, submit a blasting plan to the Engineer.

PART 2 PRODUCTS

2.01 PIPE BEDDING MATERIALS

A. TYPE 1 PIPE BEDDING

1. Type 1 Pipe Bedding includes the material placed from 4 inches (100mm) below the bottom of the pipe, around the pipe, and up to the springline of the pipe.
2. Provide Type 1 Bedding consisting of sand, sandy gravel, or gravel having a maximum 3/4 inch size (19mm) and a maximum plasticity index of 6, determined by AASHTO T89 and T90 or by ASTM D4318.
3. Where trench excavation encounters wet or unstable material, Type 1 Pipe Bedding must be free draining and non-plastic
4. 4. Refer to Standard Drawing 02221-1 and Special Provisions for other requirements.

B. SELECT TYPE 1 BEDDING

1. Select Type 1 Bedding includes the material placed from the springline of the pipe to 6 inches (15cm) over the pipe.
2. Select Type I Bedding shall consist of soil, sand or fine gravel, free from clods, lumps of frozen material, or rock exceeding 1-1/2 inches (38mm) in its greatest dimension.

3. Excavated trench material may be screened or sorted for use as backfill subject to approval of the Engineer.

4. Where trench excavation encounters wet or unstable material, Select Type 1 Bedding must be free draining and non-plastic.

C. TYPE 2 PIPE BEDDING

1. Type 2 Pipe Bedding is used as directed by the Engineer to replace unsuitable material encountered in the trench bottom.

2. Place Type 2 Pipe Bedding from the bottom of the Type 1 Bedding material to the depth required to adequately support the pipe.

3. Type 2 Bedding shall consist of granular material meeting the following gradation.

Sieve Opening	% Passing
3 Inch	100
No. 4	0-25
No. 8	0-10

D. SEPARATION GEOTEXTILE

1. The plans may require, or the engineer may direct, the use of non-woven geo-textile fabric intended to provide materials separation. The fabric will wrap all or part of the Type 1 Pipe Bedding and Select Type 1 Pipe Bedding to prevent materials migrating into the trench bottom and trench walls as shown on the plans or as directed by the engineer. The fabric shall be AASHTO M288 Class 1, 2, or 3 as specified or determined by the Engineer and shall fully comply with MPW Section 2110.

2.02 TRENCH BACKFILL MATERIALS

A. Materials from Trench Excavation

1. Backfill material obtained from trench excavations must be free of cinders, ash, refuse, organic or frozen material, boulders, or other deleterious materials. Backfill materials and placement are further described in the Execution Section of this specification.

B. Imported Backfill Material

1. Imported backfill material is from borrow source(s) outside the project limits and is used when, in the opinion of the Engineer, an adequate volume of suitable backfill material is not available within the project limits. Imported Backfill Materials must comply with the requirements of Section 2.02.A, MATERIALS FROM TRENCH EXCAVATION.

2.03 FLOWABLE FILL

A. If used, Flowable Fill is to meet the requirements of Section 2225, Flowable Fill.

2.04 TRACER WIRE

A. OPEN TRENCH

1. Furnish and install 14 AWG CCS wire with a minimum break load of 194 lbs. or solid CU with a minimum break load of 112 lbs.
2. Tracer wire must have minimum 30 mil.-thick HDPE insulation.
3. Provide 2”-6” of vertical separation between the pipeline and tracer wire.

B. WIRE CONNECTORS

1. Furnish and install lockable connectors specifically designed for direct burial, dielectric silicone gel filled, designed to prevent uninsulated wire exposure.
2. Other connector options might include non-lockable direct bury lugs equipped with silicone gel specifically designed for direct burial.

C. GROUNDING

1. Tracer wire must be properly grounded at all dead ends / stubs.
2. Grounding shall be achieved by use of 1.5 lb., drive-in magnesium grounding anode rod with a minimum of 20 feet of lead wire.
3. When the anode wire will be connected to a tracer wire access box, a minimum of 2 feet of slack wire is required after meeting final elevation.

D. TERMINATION/ACCESS BOXES

1. All locate access terminals will be designed for tracer wire and easily accessible.
2. Furnish and install SnakePit® Access Box (or approved equal) where shown on the Plans.
3. Maximum spacing between access boxes is 1,000 ft.

PART 3 EXECUTION

3.01 PROTECTION OF EXISTING PROPERTIES

A. General

1. Take precautions to protect all adjoining private and public property and facilities, including underground and overhead utilities, curbs, sidewalks, driveways, structures, and fences. Restore or replace all disturbed or damaged facilities to its original condition at Contractor’s expense.
2. Contact utility owners using the Montana One Call System for utility locates before starting work. Protect the utilities exposed during the work and prevent damaging underground utilities adjacent

to excavations. Immediately notify the utility owner of any construction damage. Repairs of damage to marked utilities are at the expense of the Contractor.

3. Re-locate existing water mains, sanitary sewers and storm drains shown on the plans, that conflict with new pipelines or structures as indicated in the contract documents. No separate payment will be made for this work unless shown as a payment item. If the Owner authorizes the relocation of mains or sewers which are not indicated in the bid documents, and the Engineer determines the work was not included in the original contract, payment will be made under the applicable sections of the General Conditions.

4. Cut and replace existing service lines interfering with trenching operations only with the engineer's permission and at the contractor's expense. Show all repaired and/or adjusted water and sewer lines on the As-Built Plans.

5. Protect existing water and sewer mains and water and sewer services from freezing at all times during construction.

B. Privately Owned Utilities

1. If any existing private utility interferes with the work in either alignment or grade, and has to be moved, the work will be performed by the appropriate UTILITY Owner, unless otherwise specified in the contract documents. Such private utilities may include gas mains, underground electrical and telephone cables, telephone poles, light poles, etc.

2. If, however, such private utility relocation is performed by the Contractor, and the relocation is not a separate payment item, payment will be made under the Section 02221 conditions covering such changes.

3. Such payment will be made only if the work is determined by the Engineer to be a change from the original contract work scope.

C. Existing Structures

1. Prevent damage to existing buildings or structures in the work area. Repair all construction related damage to the satisfaction of the Owner.

D. Existing Overhead Utilities

1. Use extreme caution to avoid conflict, contact or damage to overhead utilities during the work.

E. Exploratory Excavation

1. The location of existing buried public utilities may need to be verified by exploratory excavation before construction.

2. Where authorized by the Engineer, the Contractor will be reimbursed for exploratory excavation work at the unit price bid per hour for a backhoe/excavator with operator and a laborer to assist. Use a backhoe/excavator having at least 60 horsepower (45kw), as rated by the manufacturer.

3. The unit price per hour includes the backhoe/excavator, operator and one laborer based upon the actual time, to the nearest one-half hour, that the equipment and personnel are used in actual

excavating and backfilling operations including standby time between excavation and backfilling which allows the Engineer to make the necessary survey of the underground utilities.

4. Exercise care to prevent damaging all utilities and repair any utility damage caused by exploratory excavation.

F. Pavement Removal and Stripping

1. Where trench excavation or appurtenant structure excavation requires removing curb and gutter, concrete sidewalks, asphalt concrete pavement, or Portland cement concrete pavement, cut the concrete or pavement in a straight line parallel to the excavations edge using a spade-bitted air hammer, concrete saw or other suitable equipment to produce a straight, square and clean break. Re-cut edges broken during construction, before concrete or paving operations.

2. For trenches passing through existing pavement, cut the pavement along a neat vertical line at least 12 inches (30cm) from the trench edge. Where the neat line cut is less than 3 feet (0.9m) from the edge of the existing pavement, remove and replace the entire pavement section between trench and edge of pavement.

3. Dispose of the asphalt concrete and/or Portland cement concrete debris off-site according to applicable state and local regulations.

G. When excavating across existing gravel streets or other developed surfaces, remove the surfacing material full depth and stockpile for inclusion as trench backfill or legally dispose of the surfacing material.

H. When excavating across cultivated or sodded areas, remove topsoil full depth or to a maximum 12-inch (30cm) depth, whichever is less, and stockpile for possible project use.

I. Re-sod or reseed, as specified in the contract documents, all established lawn areas cut by trenching or damaged during the construction, in accordance with Section 2910, and/or 2920, to the satisfaction of the Engineer.

3.02 MAINTENANCE OF FLOWS

A. Maintain the flow of sewers, drains and water courses encountered during construction. Restore culverts, ditches, fences, crosswalks and structures disturbed by construction to their original condition upon completion of the work.

3.03 TRENCH EXCAVATION

A. General

1. Meet current OSHA Safety and Health Standards for all excavation, trenching, shoring, and related work.

2. Excavate at the specified locations for pipeline installations and appurtenant structures.

3. Crossings under sidewalks or curbs may be made by tunneling, if approved by the Engineer. If a portion of a sidewalk or curb is removed, use a concrete saw to make joints, compact the backfill as specified, and replace the removed section with new concrete sidewalk or curb.
4. During excavation, stockpile backfill materials away from the trench banks to assure trench wall stability. Stockpile excavated materials on only one side of the trench without obstructing existing fire hydrants, valves, manholes and other appurtenances. Assure surface drainage of adjoining areas is unobstructed.
5. Remove and dispose of all excess or unsuitable excavated materials.
6. Prevent surface water from flowing into excavations. Promptly remove all water accumulating in trench excavations. Do not permit water to accumulate in any open trench. Remove and re-lay all pipe out of alignment or grade caused by trench flooding.
7. Grade the trench bottoms to the specified lines and grades. Assure bedding material provides uniform bearing and support for each pipe section along its entire length. Excavate for bell and joints after the trench bedding is graded, limiting the excavation to the required length, depth and width for making the particular type of joint used. Backfill over-excavations with Type 2 Bedding Material.
8. No differentiation between common and rock trench excavation is made, except when listed as separate bid items on the bid proposal or bid form. Excavation includes removing and subsequent handling of all earth, gravel, bedrock or other material encountered regardless of the type, character, composition or condition of the material.
9. The use of trench digging machinery is permitted, except in places where its operation is likely to cause damage to existing structures or features, in which case hand methods are to be employed.

B. Trench Dimensions

1. Excavate to the trench dimensions specified below.
2. Width
    a. Excavate to provide room to install and join the pipe as specified. The minimum trench width is 3'-6" (1.1m), for outside pipe diameters of 18 inches (0.5m) or less. The minimum trench width is 2'-0" (0.6m) plus the outside pipe diameter, for pipe sizes exceeding 18 inches (0.5m). Maximum trench width may be specified in the contract documents.
3. Depth
    a. Excavate the trench as required for the invert grade or pipe bury as specified in the contract documents, plus 4 inches (10cm) for the Type 1 Pipe Bedding. If bedrock, boulders or large stones are encountered at the bottom of the trench, excavate at least 6 inches (15cm) below the bottom of the pipe for backfilling with Type 1 Pipe Bedding.

C. Soft or Unsuitable Trench Subgrade

1. When soft or unstable material is encountered at the trench subgrade which will not uniformly support the pipe, excavate the material to the depth directed by the Engineer and backfill to trench subgrade elevation with Type 2 Pipe Bedding.

D. Blasting

1. Obtain Engineer approval to blast for excavation. If approved, the Engineer will establish the time limits blasting will be permitted.
2. Use utmost care to protect life and property during blasting. Use only a licensed blaster with experience in the type of blasting required for the work.
3. Safely and securely store all blasting materials meeting local laws and ordinances and clearly mark all storage places “Dangerous Explosives”. Do not leave any explosives where they could endanger persons or property.
4. Blasting Rock in Trenches
    a. When blasting rock in trenches, cover the blasting area with earth backfill or approved blasting mats. Before blasting, station workers and provide danger signals to warn people and stop vehicles.
    b. Assume responsibility for all damage to property and injury to persons resulting from blasting or accidental explosions during the work.
    c. Furnish the following information to the Owner and Engineer at least 48 hours before the commencement of blasting operations: Name of the contractor’s powder man, powder man’s experience, type of shot, type of explosives and detonator being used, proof of insurance covering liability for such operation, traffic control plans and planned procedures for protecting the public.
5. Assure blasting plan meets federal, state and local ordinances. Obtain all required permits before blasting starts.

E. Pavement Damage Cause by Equipment

1. Equip all track mounted equipment operated on pavement surfacing with pads to prevent pavement damage.
2. Restore all pavement damaged by construction to its original condition.

F. Shoring, Bracing and Sheeting

1. Provide all shoring, bracing and tight sheeting required to prevent caving and protect workers, meeting current Occupational Safety and Health Act Requirements, and to protect adjacent property and structures. The cost of this work is included in the cost for trench excavation.

G. Excavation for Appurtenances

1. Make excavations for manholes, hydrants, structures and other appurtenances of the size and depth to permit compacting of backfill on all sides to the specified density. The requirements for

removing water and other applicable portions of these specifications apply to excavation for appurtenances.

3.04 DEWATERING

A. Remove all ground water encountered in trench excavations. Do not place pipe, bedding or backfill materials below the groundwater elevation established by dewatering operations. The cost of dewatering operations is considered a part of the excavation cost.

3.05 EXCAVATION STABILITY AND SAFETY

A. The stability of construction excavations and associated worker safety, including slope geometry and shoring/bracing considerations, are the responsibility of the Contractor. Meet current OSHA regulations. This may require design of temporary slopes and/or shoring by a licensed professional engineer.

3.06 TRENCH FILLING AND BACKFILLING

A. General

1. Backfill all trenches as specified immediately after grade, alignment and pipe jointing has been inspected and approved by the Engineer. Conduct any pipe testing as specified in the respective water distribution, sewerage/drainage sections. Correct all defects discovered by tests prior to backfilling.

B. Pipe Bedding Placement

1. Type 1 Bedding.

   a. Place Type 1 Pipe Bedding material 4 inches (10cm) under the pipe, around the pipe, and up to the springline of the pipe. Place in maximum lifts of 6 inches (15cm), using hand operated or other compaction methods without damaging or disturbing the pipe. Thoroughly compact each layer. Use special care to assure compaction under the pipe haunches.

   b. Place backfill material in equal lifts on both sides of the pipe for the full trench width. Take care to prevent migration of Type 1 Bedding into surrounding soils during placement and compaction

2. Select Type 1 Bedding.

   a. Place Select Type 1 Bedding material from the springline to 6 inches (15cm) over the pipe. Where wet or unstable material exists, assure the material is free draining and non-plastic.

   b. Place in maximum lifts of 6 inches (15cm) using hand or other compaction methods without damaging or disturbing the pipe. Thoroughly compact each layer.

   c. Place backfill in equal lifts on both sides of the pipe for the full trench width. Take care to prevent migration of Select Type 1 Bedding into surrounding soils during placement and compaction.

3. Type 2 Pipe Bedding.

a. Use Type 2 Pipe Bedding described in PRODUCTS SECTION as specified or as directed by the Engineer to replace unsuitable material encountered in the trench bottom, placing it from the bottom of the Type 1 Bedding material to the depth required to adequately support the pipe.

4. Separation Geotextile

a. Place Separation Geotextile where shown on the plans or where directed by the Engineer.

C. Trench Backfill

1. After the pipe bedding materials are placed and compacted as specified, backfill the trench. Use backfill material free of cinders, ash, refuse, organic or frozen material, boulders, or other deleterious materials. From the top of the Select Type 1 Pipe Bedding to 6 inches (15cm) below the ground surface, or to the subgrade elevation, material containing rock up to 8 inches (20cm) in the greatest dimension may be used.

2. Trench backfill from the top of the pipe bedding to ground surface or to the street subgrade is separated into three classifications.

a. Type A Trench Backfill is compacted backfill typically used in streets or paved areas.

b. Type B Trench Backfill is typically used for unpaved alleys, cultivated areas, borrow pits, unimproved streets or other unsurfaced areas, and other areas where compaction is less critical.

c. Type C Trench Backfill is typically used in open and unimproved areas outside of the public right-of-way.

3. Meet the backfill and compaction requirements for all the backfill types described in the contract documents.

4. Watering

a. Apply uncontaminated water, when required, at the locations and in the amounts required to compact the backfill material to the specified requirements. Maintain an adequate water supply during the work. Assure the equipment used for watering is of the capacity and design to provide uniform water application.

b. Apply water during the work to control dust and to maintain all embankment and base courses in a damp condition in accordance with these contract documents.

c. Water required for compacting trench backfill may be obtained from the municipal system if approved by the Owner, or from other sources.

5. Remove, replace, and re-compact backfill in trenches where settlement has occurred as directed by the Engineer at the contractor's expense.

6. Trench backfill types are designated as follows:

a. Type A Trench Backfill. Place trench backfill in maximum 8-inch compacted lifts within 3 percent of optimum moisture content, and compact to at least 95 percent of maximum dry density determined by AASHTO T99 or by ASTM D698.

b. Type B Trench Backfill. Place backfill in maximum 8-inch (205mm) lifts, within 3 percent of optimum moisture content, and compact to at least 90 percent of maximum dry density, as determined by AASHTO T99 or by ASTM D698.

c. Type C Trench Backfill. Place and compact Type C Trench Backfill in maximum 12-inch lifts at densities equal to or greater than the densities of adjoining undisturbed soil. Mound earth over the trench top, if so directed by the Engineer.

d. Flowable Fill. Place flowable fill as trench backfill as shown in the contract documents or as directed by the Engineer. Flowable fill may also be used as a construction expedient, substituting for any type of trench backfill, subject to approval by the Engineer and at the expense of the Contractor.

D. Replacement of Unsuitable Backfill Material

1. Remove and dispose of excavated soils that are saturated, contain deleterious materials or have characteristics that, in the opinion of the Engineer, render the soils unsuitable as backfill.

2. Replace unsuitable soils with material obtained from trench excavations within the project limits at the expense of the Contractor. If suitable replacement material is not available within project limits, obtain material from an approved borrow source, to be paid for as Imported Backfill Material.

3. Place and compact all imported material according to the applicable backfill specification requirements.

E. Backfill of Appurtenances

1. Place and compact backfill for appurtenances to finished grade around manholes, inlets, valve boxes and other underground items without disturbing appurtenance alignments.

2. Meet the backfill material, placement, and compaction requirements specified for the adjoining trench.

F. Detectable Buried Warning Tape

1. The use of warning tape is optional and if used must not be relied on as the primary locating device. Provide warning tape as described in. Bury tape a maximum 18 inches (45cm) below finish surface grade.

3.07 SURVEY MARKERS AND MONUMENTS

A. Protect all survey markers and monuments. Protection includes marking with flagged high lath and supervising work near markers and monuments. Do not disturb monuments without prior approval from the Engineer.

B. Survey markers and monuments damaged, relocated, or destroyed during construction will be replaced by the Engineer at the Contractor's cost.

3.08 CLEANUP

A. As work progresses, remove debris and complete to finish grade each portion of the work. Once the work is complete, clear debris and finish the entire site to smooth, uniform slopes presenting a neat and workmanlike appearance. Remove and dispose of all rocks brought to the surface during excavation or backfilling.

3.09 TIME AND DISTANCE OF OPEN TRENCHES

A. Perform the work so that trenches will remain open the minimum time required to accomplish the work.

B. Do not begin trench excavating until appropriate compaction equipment is at the excavation site.

C. The maximum permissible distance between backfilling/ compaction operations and the end of newly installed pipe is 500 feet (150m).

D. The maximum distance between the newly installed pipe and the excavator is to be 100 feet (30m) in existing streets (and/or alleys) and 200 feet (60m) in all other areas.

E. For each work group consisting of a trench excavator, a pipe laying crew, and a backfilling/compacting crew, the maximum allowable open ditch at any time is 700 feet (210m).

F. The maximum distance behind the end of the new pipe is 1,500 feet (460m) for gravel surfacing replacement, base placement or pavement replacement.

END OF SECTION

SECTION 02234
SUB BASE COURSE

PART 1 GENERAL

1.01 DESCRIPTION

A. This work is constructing a sub-base course of either crushed or uncrushed materials meeting the specified gradations and other quality criteria specified herein.

1.02 REFERENCES

A. American Society of Testing Materials (ASTM)

1. ASTM D698 Using 5-lb (2.5 kg) Rammer and 12-Inch (305 mm) Drop
2. ASTM D1556 Density of Soil in-Place by Sand Cone Method
3. ASTM D5821 Determining the Percentage of Fractured Particles in Coarse Aggregate
4. ASTM D6938 Nuclear Method (Shallow Depth)

B. American Association of State Highway Transportation Officials (AASHTO)

1. AASHTO T11 Amount of Material Finer Than No. 200 (0.075mm) Sieve in Aggregate
2. AASHTO T27 Sieve Analysis of Fine and Coarse Aggregate
3. AASHTO T89 Determining Liquid Limit of Soils
4. AASHTO T90 Determining the Plastic Limit and plasticity Index of Soils
5. AASHTO T176 Sand Equivalent Value of Soils and Fine Aggregate
6. AASHTO T96 Resistance to Degradation by Abrasion and Impact in the Los Angeles Machine
7. AASHTO T99 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures
8. AASHTO T191 Density of Soil in-Place by Sand Cone Method
9. AASHTO T310 In-Place density and water content of the soil and soil aggregate by

1.03 DENSITY CONTROL TESTING

A. FIELD DENSITY TESTING

1. Meet the quality control and quality assurance testing requirements in Section 01400, Contractor Quality Control and Owner Quality Assurance.

2. In-place field density tests for quality assurance are at Owner expense meeting AASHTO T191 (ASTM D1556), Sand Cone Method; or AASHTO T310 (ASTM D6938), Nuclear Densometer Methods. Quality assurance field density testing frequency is at the discretion of the Engineer.

3. Retesting of failing areas is at the expense of the Contractor.

B. Laboratory Maximum Density and Optimum Moisture

1. Moisture density curves will be provided by the Contractor for each base material supplied. These will be provided at the expense of the Contractor.

C. Material Submittals

1. Submit to the Engineer gradations, moisture density curves and other preliminary test results for sources to be used for base materials prior to delivery to the site for approval by the Engineer. If recycled materials are proposed, CBR test data must be submitted to the Engineer to assure consistency with design requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish select sub-base material meeting the applicable aggregate quality.

2.02 UNCRUSHED SUBBASE

A. Furnish material consisting of hard, durable stone, gravel or other similar materials mixed or blended with sand, stone dust, recycled concrete and/or asphalt or other binding or filler materials produced from approved sources, providing a uniform mixture meeting these specifications and compacted into a dense and well- bonded sub base. Oversize material of acceptable quality may be crushed and used in the base material, if the blend meets the specified gradations.

B. Assure the material retained on the No.4 sieve has a wear not exceeding 50 percent at 500 revolutions as determined by AASHTO T96.

2.03 CRUSHED SUBBASE

A. Furnish material having both fine and coarse crushed stone or crushed gravel, and/or natural gravel, and when approved, blended with soil, sand, screenings. recycled concrete and/or asphalt or other materials.

B. Furnish crushed gravel or stone consisting of hard, durable particles, not containing excessive flat, elongated, soft or disintegrated rock, dirt, or other deleterious matter, and having a wear not exceeding 50 percent at 500 revolutions as determined by AASHTO T96

C. Use production methods that produce a percent of fractured rock in the finished product that is constant and uniform. Crush aggregate so that at least 25% of the material is retained on the No.4 sieve and has one or more mechanically fractured faces.

2.04 GRADATION

A. Produce material, including any added binder or filler, meeting the following Table of Gradations as determined by AASHTO Methods T11 and T27:

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES

Passing	4” Minus	3" Minus	2" Minus	1 1/2" Minus	1" Minus
4 Inch	100				
3 Inch	---	100			
2Inch	---	---	100		
11/2 Inch	---	---	---	100	
1 Inch	---	---	---	---	100
No.4	25-60	25-60	25-60	25-60	25-70
No.40	10-30	10-30	10-30	10-30	10-30
No.200	2-10	2-10	2-10	2-10	2-10

B. Up to 5% "oversized" material is permitted provided that the "oversized" material passes the screen size immediately larger than the top size specified. The material between the maximum screen opening and the No.4 sieve shall be reasonably well graded.

C. Suitability of the aggregate is determined by the gradation testing of material placed in the project as required in the Contract documents, within the allowable limits described by the Table of Gradations for the particular grading specified.

D. Assure the liquid limit for the aggregate fraction passing a No.40 sieve does not exceed 25, nor the plasticity index exceed 6, as determined by AASHTO T89 and T90.

2.05 WATERING

A. Use uncontaminated water.

PART 3 EXECUTION

3.01 PREPERATION

A. Immediately before placing the base course, blade smooth and shape the underlying subgrade, sub-base or base course to the plan cross section before the base course is placed on the street. Do not place sub-base course on wet or muddy subgrade or sub-base course. Maintain at least one completed area of finished and accepted subgrade or sub-base course in advance of placing base course.

3.02 PLACEMENT AND SPREADING

A. Mix and place the material in maximum 6-inch (15 cm) horizontal layers loose thickness. Deposit and spread each load of material on the prepared subgrade, or on a completed sub-base course layer continuously without breaks. Assure hauling over the subgrade or over any completed sub base course does not damage the subgrade, sub-base or base course.

B. Spread using dump boards, spreader boxes, or moving vehicles equipped to distribute the material in a uniform layer or a windrow. Place and spread the material in a uniform layer to the specified depth without causing segregation. Once the base course is spread, blade-mix it the full depth by alternately blading the entire layer to the centerline and back to the roadway edge.

C. For multiple layers, mix each layer as specified above. Blade smooth and compact each layer before placing the succeeding layer.

D. Uniformly add water, when required, on site and place in amounts required to compact the material as necessary to aid in densification and to limit segregation. Maintain an adequate water supply during the work. Assure the equipment used for watering is of the capacity and design to provide uniform water application.

E. Apply water during the work to control dust and to maintain the base course in a damp condition.

F. Where crushed sub-base is specified, produce a product with at least 25% of the material retained on the No.4 sieve having one or more fractured faces.

G. Water required for compacting base gravel may be obtained from the municipal system if approved by the Owner, or from other sources.

H. Compact the material using appropriate tamping equipment or power rollers. Correct all irregularities or depressions that develop under rolling by scarifying the material and adding or removing material, as required, until the surface meets specifications.

I. Blade and compact alternately, as required to produce the specified surface until final inspection. Tamp the material along curbs, headers, manholes, and similar structures and all places inaccessible to rollers using approved mechanical tampers or hand tampers meet field density requirements.

3.03 FIELD DENSITY REQUIREMENTS

A. Furnish watering and rolling to obtain a minimum field density of 95 percent of the maximum dry density determined by AASHTO T99. No separate compensation is allowed for rolling and watering the sub-base course other than the sub-base course bid item or items listed on the Contract documents.

3.04 SURFACE TOLERANCES

A. Finish the sub-base course so that when tested using a 10-foot (3 m) straight edge placed on the surface with its center line parallel to the street center, the maximum surface deviation from the straight edge does not exceed 1/2-inch (12.7 mm). Additionally, the finished grade cannot deviate more than 0.1 foot (30 mm) at any point from the staked elevation and the sum of the deviations from two points not more than 30 feet (9.14 m) apart cannot exceed 0.1 feet (30 mm).

B. Perform all sub base course corrections to meet the above tolerances using approved methods and materials. Payment for patching aggregate is at the unit price bid for the sub-base course material.

END OF SECTION

SECTION 02235
CRUSHED BASE COURSE

PART 1 GENERAL

1.01 DESCRIPTION

A. This work is the placing of one or more base courses composed of crushed gravel, stone or other similar materials meeting the gradation and other quality criteria specified herein.

1.02 REFERENCES

A. American Society of Testing Materials (ASTM)

1. ASTM D698 Using 5-lb (2.5kg) Rammer and 12-Inch (305 mm) Drop
2. ASTM D5821 Determining the Percentage of Fractured Particles in Coarse Aggregate
3. (ASTM D6938) Nuclear Method (Shallow Depth)

B. American Association of State Highway Transportation Officials (AASHTO)

1. AASHTO T11 Amount of Material Finer Than No. 200 (0.075mm) Sieve in Aggregate
2. AASHTO T27 Sieve Analysis of Fine and Coarse Aggregate
3. AASHTO T89 Determining Liquid Limit of Soils
4. AASHTO T90 Determining the Plastic Limit and plasticity Index of Soils
5. AASHTO T96 Resistance to Degradation by Abrasion and Impact in the Los Angeles Machine
6. AASHTO T99 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures
7. AASHTO T176 Sand Equivalent Value of Soils and Fine Aggregate
8. AASHTO T191 Density of Soil in-Place by Sand Cone Method
9. AASHTO T310 In-Place density and water content of the soil and soil aggregate by

1.03 DENSITY CONTROL TESTING

A. FIELD DENSITY TESTING

1. Meet the quality control and quality assurance testing requirements in Section 01400, Contractor Quality Control and Owner Quality Assurance.

2. In-place field density tests for quality assurance are at Owner expense meeting AASHTO T191 (ASTM D1556), Sand Cone Method; or AASHTO T310 (ASTM D6938), Nuclear Densometer Methods. Quality assurance field density testing frequency is at the discretion of the Engineer.

3. Retesting of failing areas is at the expense of the Contractor.

B. Laboratory Maximum Density and Optimum Moisture

1. Moisture density curves will be provided by the Contractor for each base material supplied. These will be provided at the expense of the Contractor.

C. Material Submittals

1. Submit to the Engineer gradations, moisture density curves and other preliminary test results for sources to be used for base materials prior to delivery to the site for approval by the Engineer. If recycled materials are proposed, CBR test data must be submitted to the Engineer to assure consistency with design requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish aggregate base material meeting the applicable aggregate quality requirements.

2.02 UNCRUSHED SUBBASE

A. Furnish material consisting of hard, durable stone, gravel or other similar materials mixed or blended with sand, stone dust, recycled concrete and/or asphalt or other binding or filler materials produced from approved sources, providing a uniform mixture meeting these specifications and compacted into a dense and well- bonded sub base. Oversize material of acceptable quality may be crushed and used in the base material, if the blend meets the specified gradations.

B. Assure the material retained on the No.4 sieve has a wear not exceeding 50 percent at 500 revolutions as determined by AASHTO T96.

2.03 CRUSHED SUBBASE

A. Consists of both fine and coarse fragments of crushed stone or crushed gravel, and/or natural gravel, and when approved, blended with sand, finely crushed stone, crusher screenings, recycled concrete and/or asphalt or other similar materials.

B. Use crushed stone or gravel consisting of hard, durable particles of fragments of stone, free of excess of flat, elongated, soft or disintegrated pieces, dirt, or other deleterious matter, and having a percent of wear of not exceeding 50 at 500 revolutions when tested under AASHTO T96.

C. Crush material so that the percentage of fractured particles in the finished product is as constant and uniform as practical. Crush to produce material where at least 35 percent of the material retained on the No. 4 sieve has at least one fractured face.

D. Incorporate all material produced in the crushing operation and passing the No. 4 mesh sieve into the base material necessary to meet the gradation requirements.

2.04 GRADATION

A. As determined by AASHTO Methods T11 and T27, furnish material for the grading specified in the contract documents including binder or filler, which may have been added at the plant or at the site, meeting the requirements of that grading in the Table of Gradations below:

Commented [DC1]: DOWL amended; "As determined by ASTM C117 and C136,...."

TABLE OF GRADATIONS

PERCENTAGES BY WEIGHT PASSING SQUARE MESH SIEVES

Passing	1 ½" Minus	1" Minus	¾" Minus 1 1/2
Inch	100		
1 Inch	—	100	
3/4 Inch	—	—	100
1/2 Inch	—	—	—
No. 4 Sieve	25 - 60	40 - 70	40 - 70
No. 10 Sieve	—	25 - 55	25 - 55
No. 200 Sieve	0 - 8	2 - 10	2 - 10

B. Up to 5% "oversized" material is permitted provided that the "oversized" material passes the screen size immediately larger than the top size specified. The produced material between the maximum screen opening and the No.4 sieve shall be reasonably well graded.

C. Suitability of the aggregate is based on samples obtained during placement in the project within limits allowed in the table for the particular grading specified.

D. That portion of the fine aggregate passing the No. 200 sieve must be less than 60 percent of that portion passing the No. 40 sieve.

E. The liquid limit for that portion of the fine aggregate passing a No. 40 sieve cannot exceed 25, nor the plasticity index exceed 6, as determined by AASHTO T89 and T90.

Commented [DC2]: "…as determined by ASTM D4318."

2.05 WATERING

A. Use uncontaminated water.

PART 3 EXECUTION

3.01 GENERAL

A. Before placing the base course, smooth and shape the surface of the underlying subgrade, sub-base or base course to the cross section shown on the plans before placing the base course.

B. Do not place base course on a wet or muddy subgrade or sub-base course. Complete at least one area of finished and accepted subgrade, sub-base or underlying base before the placing of any base course.

3.02 PLACEMENT AND SPREADING

A. Mix and place the material in maximum 8 inches (20 centimeters) compacted layers unless otherwise approved. Deposit and spread each load of material on the prepared subgrade, or on a completed sub-base or base course layer continuously without interruption. Discontinue operating haul units over subgrade, or over any sub-base or base course completed if the haul units damage the subgrade, sub-base or base course.

B. Deposit and spread the material in a uniform layer, without segregation, to a loose depth so that when compacted, and making allowance for any filler to be blended on the road, the layer has the specified thickness.

C. Spread material using dump boards, spreader boxes, or vehicles equipped to distribute the material in a uniform layer. The material may be deposited in windrows mixed and spread as described below.

D. Construct each layer meeting these requirements. Blade smooth and thoroughly compact each layer as specified before placing the succeeding layer.

E. If segregation or moisture problems exist, or if the material was placed on the road in windrows, thoroughly blade-mix the material of the affected layer by alternately blading to the center and back to the edges of the street.

F. Uniformly add water, when required, on site and place in amounts required to compact the material as necessary to aid in densification and to limit segregation. Maintain an adequate water supply during the work. Assure the equipment used for watering is of the capacity and design to provide uniform water application.

G. Apply water during the work to control dust and to maintain the base course in a damp condition in accordance with Section 01500 under Dust Control.

H. Water required for compacting base gravel may be obtained from the municipal system if approved by the owner, or from other sources.

3.03 FIELD DENSITY REQUIREMENTS

A. Compact placed material the full width by rolling with suitable tamping equipment or power rollers. Correct all irregularities or depressions that develop during rolling by loosening the material in these places and adding or removing material, as required.

B. Perform blading and compacting alternately as required or directed, to maintain a smooth, even, uniformly compacted surface until the final inspection. Along curbs, headers, manholes, and similar structures, and at all places not accessible to the roller, compact the base course material with suitable mechanical tampers or hand tampers to reach the compaction requirements.

C. Provide the watering and rolling required to obtain a minimum field density of 95 percent of maximum dry density as determined by AASHTO T99. No separate compensation is made for rolling and watering the base course other than the base course bid item or items listed on the contract documents.

Commented [DC3]: DOWL amended; "Provide the watering and rolling required to obtain a minimum field density of 95
percent of maximum dry density as determined by ASTM D698."

3.04 SURFACE TOLERANCES

A. The base course surface when finished and tested with a 10-foot (3.0 meter) straight edge placed on the surface with its center line parallel to the center line of the street, will not have a surface deviation from the straight edge exceeding 3/8- inch (1.0 centimeter). Additionally, the finished grade cannot deviate more than 0.05 feet (1.5 centimeters) at any point from the staked elevation, and further, the sum of the deviations from two points not more than 30 feet (9.0 meters) apart cannot exceed 0.05 feet (1.5 centimeters).

B. For base course receiving asphalt concrete surfacing, the finished grade cannot deviate more than 0.02 feet (0.6 centimeters) at any point from the staked elevations, and the sum of the deviations from two points not more than 30 feet (9.0 meters) apart cannot exceed 0.02 feet (0.6 centimeters).

C. If patching of the base course is necessary to meet the tolerances, perform patching using methods and aggregates approved by the Engineer. Payment for patching aggregate is at the unit price bid for the base course material.

END OF SECTION

SECTION 02529
CONCRETE SIDEWALKS, DRIVEWAYS, APPROACHES, CURB TURN FILLETS, VALLEY GUTTERS AND MISCELLANEOUS NEW CONCRETE CONSTRUCTION

PART 1 GENERAL

1.01 DESCRIPTION

A. This work is the construction of concrete sidewalk and driveway approaches, curb turn fillets, valley gutters, new street monuments, and all other miscellaneous new concrete construction complete in place.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)

1. AASHTO M 148 Standard Specification for Liquid-Forming Compounds for Curing Concrete
2. AASHTO M 213 Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction

1.03 STANDARD DRAWINGS

A. in Appendix A applicable to this section are as follows.

1. Standard Drawing No. 02529-1 -Double Gutter Detail for Street Intersection
2. Standard Drawing No. 02529-2 -Standard Fillet
3. Standard Drawing No. 02529-3 -Type I Street Monument
4. Standard Drawing No. 02529-4 -Type II Street Monument
5. Standard Drawing No. 02529-5A -Boulevard Driveway Approach
6. Standard Drawing No. 02529-5B -Curb Walk Driveway Approach
7. Standard Drawing No. 02529-6 -Retrofit Drive Approach
8. Standard Drawing No. 02529-7A -Boulevard Alley Approach
9. Standard Drawing No. 02529-7B -Curb Walk Alley Approach
10. Standard Drawing No. 02529-8 -Accessibility Ramp
11. Standard Drawing No. 02529-9 -Swale Crossing
12. Standard Drawing No. 02529-10 -Mailbox Mounting for Curb line Delivery

PART 2 PRODUCTS

2.01 STRUCTURAL CONCRETE

A. Furnish structural concrete meeting the requirements of Section 03310, STRUCTURAL CONCRETE.

2.02 REINFORCING STEEL

A. Furnish reinforcing steel meeting the requirements of Section 03210, REINFORCING STEEL. Use 6 x 6 x 10-gauge wire mesh unless otherwise specified.

2.03 PRE-FORMED EXPANSION JOINT MATERIAL

A. Furnish joint material meeting the requirements of AASHTO M213.

2.04 GRAVEL BASE MATERIAL

A. Furnish gravel base meeting all applicable portions of Section 02235, CRUSHED BASE COURSE, and meeting gradation requirements for 1” minus material.

2.05 CURING AND PROTECTIVE COATING MATERIALS

A. Liquid Membrane-Forming Compounds for Curing Concrete

1. Use liquid membrane-forming compounds meeting the requirements of AASHTO M148, Type 1, clear or translucent. Apply the compound between April 15 and August 14.

B. Emulsified Linseed Oil Compound

1. Apply water-soluble or emulsified linseed oil compound between August 15 and April 14 as a protective coat. Assure it meets all requirements of AASHTO M148 and contains at least 2.7 pounds of linseed oil per gallon. Furnish a manufacturer’s certification showing that the formulated weight of linseed oil per gallon equals or exceeds this limit.

PART 3 EXECUTION

3.01 GENERAL

A. Construct sidewalks and driveway approaches, either new or replacement, valley gutter and curb turn fillets at the locations shown on the plans and where directed by the Engineer meeting these specifications and the applicable portions of Section 03310, STRUCTURAL CONCRETE.

B. The use of slip form machines is prohibited for items in this section unless otherwise specified or permitted by the Engineer.

3.02 FOUNDATION PREPARATON

A. Excavate the foundation to the specified depth. Assure the subgrade or base course for the concrete has a firm and even surface and is compacted meeting Section 02230, STREET EXCAVATION, BACKFILL, AND COMPACTION.

B. Place and compact at least 3 inches (76 mm) of gravel base material to a firm, even surface. This requirement is waived for concrete if it is to be installed on street base course material exceeding 3 inches (76 mm) or more in thickness.

3.03 FORMS

A. Furnish forms to produce the shape, lines, and dimensions shown on the plans and/or drawings. Assure forms prevent leakage of mortar and are maintained in proper position and accurate alignment. Thoroughly clean and oil forms with an approved form oil before placing concrete and remove forms only after the concrete has hardened sufficiently to support all loads without damage.

B. Form radii using flexible or curved metal forms set to the required curvature. Use wood forms only with the Engineer's approval. Radii may be formed by using segments of straight forms if the length of the straight segment does not exceed one-tenth of the length of the radius.

C. Use 6-inch (15 cm) forms and 6-inch (15 cm) pre-formed expansion joint material for concrete 6 inches (15 cm) in depth.

3.04 REINFORCEMENT

A. Place and hold in position reinforcement meeting the contract requirements before placing the concrete.

3.05 PLACING CONCRETE

A. Assure the subgrade is compacted and brought to specified grade before placing concrete. Dampen the subgrade immediately before placing the concrete. Spade and tamp the concrete into the forms providing a dense, compacted concrete free of rock pockets. Float, finish and broom the exposed surfaces. Each placing/finishing crew shall have at least one ACI Flatwork Finisher Technician level or above, on site at all times.

B. Assure the rate of concrete placement does not exceed the rate at which the various placing and finishing operations can be performed in accordance with these specifications.

3.06 STRIPPING FORMS AND FINISHING

A. Forms

1. Remove forms when the concrete is sufficiently set to prevent chipping or spalling. When forms are removed before the curing period has expired, protect the concrete edges with moist earth or spray edges with curing compound. Clean, oil, and examine all forms for defects before they are used again.

B. Finishing

1. Finish the concrete surface true to the lines and grades shown on the plans. Float the concrete surface using a magnesium float to a smooth and uniform surface. Plastering of the surface is prohibited. Edge all outside edges of the slab and all joints using a ¼-inch (6.5 mm) radius-edging tool. After concrete has hardened sufficiently, give the surface a broom finish. Assure the broom strokes are square across the concrete from edge to edge, overlapping adjacent strokes. Broom without tearing the concrete. Assure the broomed finish produces regular corrugations not exceeding 1/8-inch (3 mm) in depth.

3.07 CURING

A. Curing meeting Section 03310, STRUCTURAL CONCRETE, requirements.

3.08 JOINTS

A. Extend isolation joints the full depth of the concrete and fill using ½-inch (12 mm) thick, pre-formed joint filler as specified in Section 02529.3.3. Place isolation joints meeting this requirement where new concrete abuts existing concrete. Form isolation joints around all appurtenances, such as manholes, utility poles, etc. extending into and through the concrete.

B. Install pre-formed joint filler between concrete and any fixed structure, such as a building or bridge. Assure all expansion joint materials extend the full depth of the concrete. Place isolation joints at radius points, junctions with existing concrete, and opposite to or at expansion joints in adjacent concrete. Form cold joints at unions of consecutive pours as shown on the plans or directed by the Engineer. Assure the cold joint is vertical, the full depth of the concrete, and tooled to a ¼-inch (6.5 mm) radius.

C. Divide sidewalk into sections using contraction joints formed by a jointing tool or other approved methods. Extend the contraction joints into the concrete for at least one-fourth of its depth and be approximately 1/8-inch (3 mm) wide. Unless otherwise directed, space contraction joints at maximum 10-foot (3 m) intervals or at a distance equal to the sidewalk width, whichever is less. In continuous sidewalk runs, install isolation joints at the location of a regular contraction joint if the distance between isolation joints does not exceed 300 feet (91 m).

3.09 BACKFILL

A. In areas adjacent to existing lawns, backfill the top 4 inches (100 mm) using black loam or good topsoil suitable for lawn growth. Place it out from the sidewalk or driveway to replace turf or lawn removed during installation. Place the backfill level with the top of the curb, immediately adjacent to the curb, graded and blended to match the existing undisturbed lawn area.

B. Where lawns do not exist, backfill the top 4 inches (100 mm) with impervious dirt and place to meet the typical sections shown on the plans.

C. Compact backfill to prevent settlement and level the surface to a neat appearing and free draining surface.

3.10 TOLERANCES

A. Assure all items of construction covered by this section present clean, uniform surfaces and lines free of irregularities and distortions. Plane surfaces and vertical tangent lines are tested with a 10-foot straightedge and cannot deviate more than

¼-inch (6.5 mm) from the straightedge.

3.11 MISCELLANEOUS NEW CONCRETE CONSTRUCTION

A. Construct new street monuments, new street light bases, and other miscellaneous concrete construction in accordance with detail drawings.

END OF SECTION

SECTION 02600
LOW PROFILE CASCADE AERATOR (LPCA)

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers furnishing a complete cascade post aerator system as specified herein. The cascade post aerator, further described as a low-profile cascade aerator (LPCA), is designed for installation in a concrete basin as shown on the Plans and Drawings and shall be a rectangular, open channel type, low profile, free flowing aerator with hydraulic loading capacity of 1.29 MGD (minimum daily flow), 1.29 MGD (maximum), and 1.29 MGD average daily flow. Based on influent dissolved oxygen concentrations (D.O.) of 0-10 mg/l, a minimum average daily D.O. reading of 4.0 mg/L is required.

1. GENERAL:

   a. The LPCA equipment shall consist of a plurality of channel dividers with Inlet Flow Control Optimizer / Equalizer Gate and weirs. The inlet weirs shall be for flow control, and each shall increase in height from one channel to the next. Each channel shall be provided with a plurality of low head aeration baffles spaced as shown on plans. Each aeration baffle shall be provided with patented trapezoidal air infusion plates as shown to provide optimum transfer efficiency. At peak flow the system will offer even flow distribution to each channel. To prevent short circuiting and critical for system process performance, channels and aeration baffles are constructed so as to eliminate all gaps.

   b. Equipment furnished under this section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations by the named equipment manufacturer.

2. CONTRACTOR

   a. Contractor will furnish all labor, materials, equipment, and incidentals required to provide a complete LPCA system as specified herein.

3. MANUFACTURER

   a. The manufacturer of the LPCA equipment must be Jim Myers & Sons, Inc. Contact information for the technical sales representative is as follows:

      Jim Brettman – Technical Sales Manager

      Office Phone: (704) 554-8397 ext. 1102

      Mobile Phone: (704) 905-3612

      Email: jbrettman@jmsequipment.com

   b. The manufacturer of the LPCA equipment shall be vested with unit responsibility for the proper function of the complete low profile cascade aerator system as specified. The patented LPCA with trapezoidal air infusion plates shall be a current, standard product of a manufacturer having extensive experience and regularly engaged in the production of such equipment with proven performance test results.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1.	ASTM	American Society for Testing Materials
2.	ASTM A167	Type 304L & 316L Stainless Steel
3.	ANSI	American National Standards Institute
4.	AWS	American Welding Society

1.03 SUBMITTALS

A. Submit for approval the following

1. Provide one electronic manual in PDF format and/or four (4) complete approval submittal manuals. Manuals shall be bound and include scope, process calculations, catalog cuts, and drawings.
2. Manufacturer's literature, illustrations, and engineering data including total weight of each unit, connection details, and performance data.
3. Drawings shall show dimensions, overall arrangement of equipment and materials of construction.
4. Literature describing the equipment and showing all important details of construction and dimensions. Dimensions shall show overall size and space requirements including that for installation, leveling, dismantling and maintenance.
5. Cross sections and details, as to show that all components are in conformance with the intent of the specification and are satisfactory from the standpoint of design and physical arrangement.

B. Operations and Maintenance Manuals

1. Submit one electronic Manual in PDF format and/or four (4) complete operation and maintenance manuals. Manuals shall be bound and include reinforced 8.5" x 11" paper, 11" x 17" B-size drawings when practical, and individually sleeved D-size drawings.
2. The manual shall include: Equipment Introduction and Operation, Warranty, Troubleshooting, Maintenance, and Drawings.

1.04 QUALITY ASSURANCE

A. Basis of Design: The structural, mechanical and process design for the cascade post aerators are based on information provided by the first-listed low profile cascade aerator Manufacturer. The cost of any changes and modifications due to furnishing equipment other than that specified shall be borne solely by the CONTRACTOR. The CONTRACTOR shall also be responsible for any substitute equipment furnished complying with the full intent of the specifications and be responsible for any patent infringement to the LPCA**.**

B. Fundamental changes in the configuration of the post aerator system will not be allowed. LPCA equipment submitted as equivalent products shall not require additional basin area or depth to achieve the designated performance requirements. The CONTRACTOR shall submit complete drawings,

specifications and supporting documents, identifying all proposed changes, a list of installations and certified performance data, to the ENGINEER for approval at least 14 days prior to bid date.

C. Responsibilities

1. The LPCA Manufacturer is responsible for delivery of equipment and supplies required under these specifications. The CONTRACTOR is responsible for proper off-loading and storage at the delivery location, and coordination and integration of all equipment required for installation in the concrete basin, and all other associated work shown on the drawings and specified in the Contract Documents. The CONTRACTOR is responsible for ensuring that the LPCA system shall be properly coordinated and will function as a unit in accordance with these specifications. The CONTRACTOR shall bear ultimate responsibility for equipment coordination, installation, operation, and guarantees.

D. Workmanship

1. Workmanship in the fabrication of the LPCA system shall be of high quality and include the following requirements. The assembled channel aeration baffle assembly shall have members that are straight and true. Structural distortions, warps, and other defects shall not be present in the aeration assemblies before or after installation in the basins. The topmost corners of all Air Infusion Plates shall be ground round and smooth.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The trapezoidal Air Infusion Plates and Air Infusion Baffles shall be factory assembled to the channel dividers and shall be shipped in sections. All equipment shall be shipped with suitable in-transit protection.

B. Lifting straps in lieu of chains are to be employed when applicable (by CONTRACTOR).

C. Equipment shall be stored and protected in accordance with the manufacturer's recommendations.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The equipment shall be manufactured by:

1. Jim Myers & Sons, Inc. (JMS)
2. Smallberry Manufacturing
3. No ‘Or Equals’ will be accepted

B. The equipment described by this specification defines minimum equipment requirements as supplied by the first-listed manufacturer. All unforeseen costs associated with any deviation from this specification shall be the sole responsibility of the Contractor.

C. The equipment shall be the product of a manufacturer engaged in the design and manufacture of similar equipment in successful operation in similar applications. The manufacturer shall have experience with

20 installations of the same type of equipment as specified herein with successful operation for a minimum of 10 years.

D. Pre-qualification requires manufacturers to submit the following 30 days prior to bid:

1. A list of at least 10 previous installations, including contact information, of similar size, design, and complying with the requirements as set forth within this specification.
2. Preliminary drawings and process calculations specific to this project.
3. A letter stating that their proposed design complies with all requirements as specified herein. If there are deviations from the specification a letter must address each deviation in detail.
4. Equipment shall be manufactured in the United States by US citizens fully certified by the American Welding Society for the tungsten inert gas (TIG) welding process to standard AWS D1.6. Letters of current certification shall be provided prior to bid and within the submittals.

2.02 MATERIALS

A. LPCA equipment shall be supplied by Manufacturer and shall be fabricated of Type 304 stainless steel and shall include all necessary stainless steel anchor bolts, seals, and accessories.

1. Channels, Air Infusion Plates, Aeration Baffles and Closure Plates are to be fabricated with Type 304 SS with a minimum thickness of 0.120” (11 gauge).
2. Influent Flow Control Optimizer / Equalizer Gate, trapezoidal in design, is to be fabricated with Type 304 SS.

B. Hardware: All field assembly anchor bolts, bolts, nuts, washers and seal material shall be supplied by Manufacturer:

1. Nuts, fasteners, and anchor bolts (3/8” diameter) are to be Type 304 SS.
2. Seal Material: 3M 3/8” round ribbon sealant to be provided by Manufacturer.

2.03 LPCA SYSTEM

A. The LPCA system shall be fabricated in accordance with the details indicated on the drawings and the requirements specified herein.

B. The LPCA is a static system design and is designed and constructed for the minimum flow and maximum flow as specified and utilized in the treatment plant’s post aeration process to increase the aerobic effluent dissolved oxygen content.

C. The LPCA as specified is designed for installation (insertion) in the treatment plant post aeration concrete structure (by CONTRACTOR) as shown on the Plans, and utilized to increase the plant effluent dissolved oxygen content. The LPCA shall be the last piece of process equipment, located at the outfall of the wastewater treatment plant.

D. The unit shall be structurally reinforced by attaching structural bracing to the top of the channel dividers as shown on the drawings. The unit shall be sealed under the channel dividers and anchored in

the concrete channel as directed by the manufacturer's instructions. Said sealing of all channels to the concrete channel floor to eliminate all gaps is critical for system process performance.

E. The Influent Flow Control Optimizer / Equalizer Gate, for the specified design minimum and maximum influent hydraulic loading, directs the variable influent flow to the appropriate channel or channels to optimize system performance and offers a patented integral air infusion plate for greater aeration performance during periods of low flow. Air infusion plates and aeration baffles will be trapezoidal shaped to optimize air infusion at minimum flows and achieve the effluent dissolved oxygen concentration at the full range of flow per 1.1.A. At peak flow the system must be designed to offer even flow distribution to each channel.

PART 3 EXECUTION

3.01 INSTALLATION

A. GENERAL:

1. The CONTRACTOR shall install the aerator equipment where indicated on the contract drawings and in strict accordance with the manufacturer's recommendations.
2. Set all anchor bolts using templates as required.
3. The LPCA shall be fabricated for insertion into a concrete basin/channel as shown on the Drawings.
4. All smooth concrete surfaces shall be true plane within 1/4" in 10'-0" as determined by a 10'-0" straight edge placed anywhere on the surface, in any direction.
5. Abrupt irregularities shall not exceed 1/8".
6. The unit shall be structurally reinforced by attaching structural angle bracing to the top of the channel dividers as directed by the manufacturer's instructions.
7. Per manufacturer's instructions, the unit shall be sealed under the channel dividers and aeration baffles by Contractor with seal stripping (furnished by Manufacturer) and anchored in the concrete basin to eliminate short circuiting. Said sealing of all channels to the concrete encasement floor to eliminate all gaps is critical for system process performance.

B. Concrete basin (by CONTRACTOR) as shown on the Plans is to include influent and effluent chambers to be sized so as to not exceed indicated maximum water elevations. Influent chamber (by CONTRACTOR) to include energy dissipation device if necessary to reduce water velocity impact on influent distribution and to evenly distribute flow to Influent Flow Control Optimizer / Equalizer Gate.

C. CONTRACTOR will provide concrete encasement/basin with the sloped floor and dimensions as specified on Contract Drawings. CONTRACTOR understands the slope and finish tolerances are critical to the performance of the post aerator and are as noted in 3.1.B., Contract Drawings and Manufacturer's recommendations.

D. CONTRACTOR must connect accessory parts as required to ensure a complete and operable system as intended. Contractor to exercise great care in erecting and leveling the weir plates so that the units are at the elevations shown on the Drawings or specified herein, and to ensure the aeration system is

mounted and sealed to floor and walls to eliminate short-circuiting as intended and per Manufacturer's Instructions.

E. LUBRICANTS AND LUBRICATING EQUIPMENT

1. Anti-seize shall be applied to the threads of all stainless-steel bolts before assembly at the factory and field assembly.

3.02 WARRANTY

A. The MANUFACTURER shall guarantee in writing that the equipment furnished is appropriate for the intended service and shall be free of manufacturing and fabrication defects in material and workmanship for a period of one (1) year after the equipment is satisfactorily placed into service. If the equipment is not placed into service within 6 months of delivery, the 1-year guarantee period shall commence 6 months after delivery.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Field Services: The CONTRACTOR shall provide the following services in addition to any other services specified herein and required by these Specifications.

1. A factory trained manufacturer's representative shall be provided for a minimum of one (1) trip and a minimum of eight (8) hours to provide installation supervision, start-up and field-testing services, and O&M training services. The installation services shall be coordinated between the CONTRACTOR and the Manufacturer. The start-up and field-testing services, and the O&M services shall be coordinated with the ENGINEER.

2. After installation supervision and field-testing services by the manufacturer, the CONTRACTOR shall submit to the ENGINEER, a certification letter on the manufacturer's letterhead and signed by the manufacturer certifying that the equipment was installed per the manufacturer's recommendations.

3. The manufacturer shall provide start-up reports covering installation inspection and start up activities.

4. The manufacturer shall provide operator training to all required plant personnel.

B. All costs, including travel, lodging, meals, and incidentals for Manufacturer service shall be included in the CONTRACTOR'S bid.

PART 4 MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Payment for the LPCA will be made on a lump sum basis including but not limited to:

1. Materials, labor, and incidentals required to construct the concrete basin.

2. Materials, labor, and incidentals required to install the LPCA.

END OF SECTION

SECTION 02660
HDPE PIPES, FITTINGS, AND JOINTS

PART 1 GENERAL

1.01 SUMMARY

A. This specification covers the material (pipe and fittings), joining methods and general installation practice for high density polyethylene pipe (HDPE) piping systems for storm water utility use as indicated on the Drawings.

1.02 SUBMITTALS

A. Submit product data to the Engineer for review in accordance with the Section 01340 for all pipe and appurtenances.

B. Furnish in duplicate to the Engineer confirmation that product shipped meets or exceeds the standards set forth in this specification. This shall be in the form of a written document from the manufacturer attesting to the manufacturing process meeting the standards.

C. Provide a statement in writing from the HDPE pipe manufacturer that it is listed with the Plastic Pipe Institute as a qualified extruder for the polyethylene resin being used to manufacture the pipe for this project.

D. Provide a statement that personnel responsible for fusing the pipe have been trained and qualified.

E. Contractor shall also submit the following to the Engineer for approval:

1. Certified dimensional as-built drawings/profile of all installed pipe, specials and fittings.

2. Details of fittings and specials such as elbows, wyes, tees, outlets, connections, test bulkheads, bosses and nozzles or other specials where shown on the Construction Drawings, which indicate amount and position of reinforcement. All fittings and specials shall be properly reinforced to withstand the internal pressure both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents. Shop Drawings shall clearly detail special castings indicating all pertinent dimensions.

3. The Supplier of the material shall submit, through the Contractor, a Certificate of Compliance that the pipe, fittings and other products or materials furnished for this project have been inspected at the plant and comply with all applicable provisions of these Specifications. The Contractor shall submit these certificates to the Engineer prior to installation of the pipe materials.

1.03 REFERENCES

Unless otherwise specified, references to documents shall mean the latest published edition of the referenced document in effect at the bid date of the project.

A. ANSI/AWWA

1. ANSI/AWWA C901 Polyethylene (PE) Pressure Pipe and Tubing, ½ In. (13 mm) Through 3 In. (76 mm) for Water Service
2. ANSI/AWWA C906 Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission
3. AWWA M55 Manual of Water Supply Practices, PE Pipe–Design and Installation

B. Plastic Pipe Institute (PPI)

1. PPI Handbook of Polyethylene Pipe – 2009 (2ndEdition)
2. PPI Municipal Advisory Board (MAB) Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe
3. PPI Material Handling Guide for HDPE Pipe and Fittings
4. PPI TR-38 Bolt Torque for Polyethylene Flanged Joints
5. PPI TN-42 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects
6. PPI TR-46 Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe

C. ASTM

1. ASTM F 585 - Standard Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewers
2. ASTM F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
3. ASTM F 905 - Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
4. ASTM F 1055 - Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe
5. ASTM F 1290 - Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
6. ASTM F1417 - Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
7. ASTM F 1962 - Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings
8. ASTM F 2164 - Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
9. ASTM F2206 - Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock
10. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
11. ASTM F 2620 - Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
12. ASTM D 2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping
13. ASTM F 2880 - Standard Specification for Lap-Joint Type Flange Adapters for Polyethylene Pressure Pipe in Nominal Pipe Sizes 3⁄4 in. to 65 in.
14. ASTM D 3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
15. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

PART 2 PRODUCTS

2.01 MATERIALS

A. **Pipe Sizes**

1. 14” DR-32.5 HDPE (IPS)

B. **Resin and Material Requirements**

1. All material shall be manufactured from a PE 4710 resin listed with the Plastic Pipe Institute (PPI) as TR-4. The resin material shall meet the specifications of ASTM D 3350 with a minimum cell classification of 445474C. HDPE pipe and fittings shall contain no recycled compounds except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. HDPE products shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids, or other injurious defects.

C. **HDPE Pipe Requirements**

1. Pipe shall be made of HDPE material with a minimum material designation code of PE4710 and with a minimum Cell Classification as noted in 2.01.A. The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black of not less than 2 percent. The manufacture of the HDPE resin shall certify the cell classification indicated.

2. Pipe sizes 3” and large shall have a manufacturing standard of ASTM F 714, while pipe smaller than 3” shall be manufactured to the dimensional requirements listed in ASTM D 3035. Dimension Ratio (DR) and/or Outside Diameter (IPS/DIPS) shall be as specified on plans.

3. Pipe shall meet AWWA C901 (1/2” to 3”) or AWWA C906 (4” to 63”) and shall be listed as meeting NSF-61.

4. Pipe shall be manufactured by an ISO 9001 certified manufacturer. The pipe manufacturer shall have an ongoing Quality Control program for incoming and outgoing materials and shall assure that the pipe will meet the material requirements of this specification. HDPE resins for manufacturing of pipe shall be checked for density, melt flow rate, and contamination. The facility shall have the necessary testing equipment to verify that pipe meets the AWWA and NSF standards. Pipe shall be checked for outside diameter, wall thickness, length, and surface finish on the inside and outside. The Manufacturer’s production facilities shall be open for inspection by the Owner or Engineer.

5. All pipe shall be color coded for the intended service. The color coding shall be permanently co-extruded stripes on the pipe outside surface as part of the pipe’s manufacturing process. Painting HDPE pipe to accomplish color coding is not permitted. Color coding shall be as follows:
    a. Sewer – green
    b. Water – blue
    c. Reclaim – purple

D. **HDPE Fittings**

1. Butt Fusion Fittings - Fittings shall be made of HDPE material with a minimum material designation code of PE4710 and with a minimum Cell Classification as noted in 2.01.A. Fittings shall have a minimum pressure rating equal to or greater than the pipe to which they are joined unless otherwise specified on the plans or accepted by Owner/engineer. All fittings shall meet the requirements of AWWA C901 or C906.

    a. Molded fittings shall comply with the requirements of ASTM D 3261.

    b. All fabricated elbows, tees, reducing tees and end caps shall be produced and meet the requirements of ASTM F 2206, as manufactured by ISCO Industries, Inc or other approved manufacturer holding an ISO 9001 quality system certificate. Each fitting will be marked per ASTM F 2206 section 10 including the nominal size and fitting EDR, which will meet or exceed the pipe DR identified for the project. Fabricated fittings shall be manufactured using a McElroy DataLogger to record fusion pressure and temperature, and shall be stamped with unique joint number that corresponds to the joint report. A graphic representation of the temperature and pressure data for all fusion joints made producing fittings shall be maintained for a minimum of 5 years as part of the quality control and will be available upon request of Owner. Test results to validate ASTM F 2206 section 7.3 and 9 shall be provided to Owner or Owner's representative upon request.

    c. Socket fittings shall meet ASTM D 2683.

2. Electrofusion Fittings - Fittings shall be made of HDPE material with a minimum material designation code of PE 4710 and with a minimum Cell Classification as noted in 2.01.A. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a minimum pressure rating equal to or greater than the pipe to which they are joined unless otherwise specified on the plans. For potable water systems, all electrofusion fittings shall have AWWA approval.

3. Bolted Connections – Flanged and Mechanical Joint Adapters can be made to ASTM D 3261 or if machined, must meet the requirements of ASTM F 2206. Flanges and MJ Adapters shall be fused onto the pipe and have a minimum pressure rating equal to or greater than the pipe unless otherwise specified on the plans.

    a. Flange Adapters shall meet the dimensional and material requirements of ASTM F 2880.

    b. Metallic back-up rings (Van-Stone style lap joint flanges), shall have a radius on the inside diameter of the bore so as to be compatible with HDPE Flanges. Back up rings shall have bolt pattern that will mate with AWWA C207 Class D (or B or E), ASME/ANSI B 16.5 Class 150, ASME/ANSI B 16.1 Class 125, or ASME/ANSI B16.47 Series A.

    c. Flange assemblies shall be assembled and torqued according to PPI TN-38, "Bolt Torque for Polyethylene Flanged Joints."

    d. Where shown on the drawings, 4" and larger transitions to mechanical joint fittings and valves shall be accomplished using a MJ Adapter with kit. The D.I./HDPE mechanical joint adaptor shall consist of:

1) A molded or fabricated HDPE mechanical joint transition fitting.
2) A rubber gasket.
3) A mechanical joint backup drive ring.
4) Corten mechanical joint tee bolts.

4. Mechanical Fittings: The use of mechanical coupling and saddles shall be approved by the Owner or engineer prior to installation. Mechanical Fittings shall be designed for use and compatible with HDPE pipe. Mechanical fittings shall have a pressure rating equal to or greater than the pipe.

   a. Couplings without self-restraining capabilities (integrated serrated teeth or grippers) shall include a plan for external restraint or isolation from pipeline generated forces.

   b. Mechanical Saddles shall have wide straps for distribution of clamping loads. No U- bolts shall be allowed.

   c. When required by mechanical coupling manufacturer, pipe stiffeners shall be employed to support the interior wall of the HDPE. The stiffeners shall support the pipe's end and control the "necking down" reaction to the pressure applied during normal installation. The pipe stiffeners shall be formed of 304 or 316 stainless steel, with a wedged style design to fit the HDPE manufacturers published average inside diameter of the specific size and DR of the HDPE.

E. **Fusion Unit Requirements**

1. All Fusion Equipment, whether new or used, rented or owned, shall comply with the requirements of ISO 12176-1 "Equipment for Fusion Jointing Polyethylene Systems".

2. If the contractor owns butt fusion equipment, the equipment must be serviced within 3 months prior to use for this project. The machine must be environmentally friendly and in satisfactory working order. The hydraulic system must be leak free. The pressure gage and thermometer must be checked for accuracy. For projects with pipe quantities of 5000' or longer, the fusion equipment should be serviced by a McElroy Authorized Service and Repair Center with at least one McElroy Certified Master Mechanic on staff within 3 months from the first fusion on the project.

3. Rental Fusion Equipment must be maintained by a McElroy Authorized Service and Repair Center with at least one McElroy Certified Master Mechanic on staff. When requested by Owner or his authority, an inspection report detailing the components inspected within 3 months prior to arrival at jobsite will be provided.

F. **Manufacturer**

1. All Pipe, Fittings, and Fusion Equipment shall be provided by one manufacturer.

2.02 PIPELINE LOCATING MATERIALS – PRESSURE APPLICATIONS ONLY

A. Tracer Wire:
All HDPE pipe 4" and greater shall be installed with an extra high-strength, copper clad steel tracer wire including 30 mil HDPE jacket that has a minimum average break load of at least 130 lbs. The jacket shall be colored based on pipe service, with blue for potable water or green for sewer. Tracer wire gauge shall

be 14 AWG, 12 AWG, or 8 AWG depending upon application and installation procedure. This wire shall to be continuous and brought up into access points at the ends of each line segment with splices made only by methods per the equipment manufacturer's recommendation. All miscellaneous splicing components shall be furnished and installed by the Contractor.

B. Access Points
Provide SnakePit® Access Points as manufactured by Copperhead Industries. SnakePit® Access Points shall be of the Two-Terminall Switchable Lid type with Blue lid. Access points shall be Copperhead Industries Part Number **RB14*2T-SW**. Provide all other incidental materials related to the installation of the access points including but not limited to grounding rods and wire.

PART 3 EXECUTION

3.01 GENERAL

A. All HDPE pipe and fittings shall be cut, joined, and installed in accordance with the manufacturer's recommendations. Joining, laying, and pulling of polyethylene pipe shall be accomplished by personnel experienced in working with polyethylene pipe systems.

3.02 TRANSPORTATION, UNLOADING, AND STORAGE

A. The manufacturer shall package product in a manner designed to deliver the pipe and fittings to the project neatly, intact and without physical damage. During transportation each pipe shall rest on suitable pads, strips skids, or blocks securely wedged or tied in place. The transportation carriers shall use appropriate methods and intermittent checks to insure the pipe is properly supported, stacked and restrained during transportation such that the pipe is not nicked, gouged, or physically damaged. The transportation carrier shall provide tarpaulins to cover any potable water pipe subject to exposure to diesel exhaust or smoke.

B. During loading, transportation, and unloading, every precaution should be taken to prevent damage to the pipe. Cuts or gouges that reduce the wall thickness by more than 10% is not acceptable and must be cut out and discarded.

C. Handle the pipe in accordance with the PPI Handbook of Polyethylene Pipe (2nd Edition), Chapter 2. All pipe and accessories shall be loaded and unloaded by lifting with hoists or by skidding in order to avoid shock or damage. Under no circumstances shall materials be dropped. Pipe handled on skidways shall not be rolled or skidded against pipe on the ground. Slings, hooks or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or interior of the pipe. All pipe and fittings shall be subjected to visual inspection at time of delivery and before they are lowered into the trench to be laid. Joints or fittings that do not conform to these specifications will be rejected and must be removed immediately by the Contractor.

D. Materials, if stored, shall be kept safe from damage. The contractor shall be responsible for all security, damage and loss of pipe, excluding Acts of God. The interior of the pipe as well as all sealing surfaces of mating components (i.e. flange faces) shall be kept free from dirt or foreign matter at all times.

E. Pipe shall not be stacked higher than the limits recommended by the manufacturer. The bottom tiers shall be kept off the ground on timbers, rails, or concrete. Pipe shall not be stored close to heat sources.

F. The open ends of all sections of joined and/or installed pipe (not in service) shall be plugged to prevent animals or foreign material from entering the pipe line or pipe section. The practice of stuffing cloth or paper in the open ends of the pipe will not be permitted. Waterproof nightcaps of approved design may be used but they shall be so constructed that they will prevent the entrance of any type of natural precipitation into the pipe and will be secured to the pipe in such a manner that the wind cannot blow them loose.

G. Where possible, the pipe shall be raised and supported at a suitable distance from the open end such that the open end will be below the level of the pipe at the point of support.

3.03 PIPE INSPECTION

A. All pipe and fittings shall be subjected to visual inspection at time of delivery and before they are installed or lowered into the trench to be laid. Defective, damaged, or unsound pipe will be rejected. Cuts, punctures, or gouges that penetrate or reduce the wall thickness by 10% or more are not acceptable and must be removed and discarded. Joints or fittings that do not conform to these specifications will be rejected and must be removed immediately by the Contractor.

3.04 HANDLING PIPE

A. The handling of the pipeline shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Sections of the pipes with cuts and gouges exceeding 10 percent of the pipe wall thickness or kinked sections shall be removed and the ends rejoined.

B. Refer to the PPI Material Handling Guide for HDPE Pipe and Fittings for recommendations, guidelines and instructions regarding the handling, lifting, loading, storing and installing polyethylene pipe and fittings.

3.05 PIPE JOINING AND INSTALLATION

A. **Direct Burial**

1. Buried HDPE pipe and fittings shall be installed in accordance with ASTM D 2321 or ASTM D 2774 for pressure systems and AWWA Manual of Practice M55 Chapter 8. The Design Window identified in AWWA M55 Chapter 5 (page 65 of 2006 version) shall be considered acceptable design and installation conditions.

2. Pipe embedment - Embedment material should be Class I, Class II, or Class III materials as defined by ASTM D-2321 Section 6 or Type 1 and 2 per Section 02225. The use of Class IV and Class V materials is not recommended; however, it may be used only with the approval of the engineer and appropriate compaction.

3. Bedding: Pipe bedding shall be in conformance with ASTM D 2321 Section 8. Compaction rates should be as specified in ASTM D 2321. Deviations shall be approved by the engineer.

4. Haunching and backfill shall be as specified in ASTM D 2321 Section 9 with Class I, II, or III materials. Compaction shall be in excess of 85% Proctor.

B. **Trenchless Installation Methods**

1. Installation of HDPE Pipe by Directional Boring shall follow the guidelines for ASTM F 1962 or PPI TR-46.

C. **Fusion Joining Requirements:**

1. All HDPE pipe shall be joined to itself by the heat fusion process which produces homogeneous, seal, leak tight joints. Tie-ins between sections of HDPE pipe shall be made by butt fusion whenever possible.

2. Butt Fusion:
The pipe shall be joined by the butt fusion procedure outlined in ASTM F 2620 or PPI TR-33. All fusion joints shall be made in compliance with the pipe or fitting manufacturer's recommendations. Fusion joints shall be made by qualified fusion technicians per PPI TN-42. A record or certificate of training for the fusion operator must be provided that documents training to the fundamentals of ASTM F 2620. Considerations should be given to and provisions made for adverse weather conditions, such as temperatures below freezing, precipitation, or wind, which is accepted by the Owner/engineer.

3. Electrofusion:
Electrofusion joining shall be done in accordance with the manufacturers recommended procedure. Other sources of electrofusion joining information are ASTM F 1290, PPI TN 34, and PPI Municipal Advisory Board (MAB) Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe. The process of electrofusion requires an electric source, commonly called an electrofusion processor that has wire leads and a method to read electronically (by laser) or otherwise input the barcode of the fitting. The electrofusion processor must be capable of reading and storing the input parameters and the fusion results for later download to a record file. Qualification of the fusion technician shall be demonstrated by evidence electrofusion training within the past year on the equipment to be utilized for this project.

D. **Fusion Operators:**

1. The employer of the fusion machine operator is responsible for the fusion joint quality of the fusion weld made by that individual. The employer is responsible for documenting all qualification and training records of that individual.

2. All HDPE fusion equipment operators shall be qualified to the procedure used to perform pipe joining. Fusion equipment operators shall have current, formal training on all fusion equipment employed on the project. Training received more than two years prior to operation with no evidence of activity within the past 6 months shall not be considered current.

3. Operators or their supervisor must have a current McElroy Fusion Training Certificate for the equipment to be used on the project.

4. When the fusion machine operator is employed by the HDPE pipe and fusion machine supplier, the supplier shall maintain an ISO 9001 Certified Quality Management System.

E. **Butt Fusion Equipment:**

1. For 6” and larger pipe sizes, the pipe butt fusion machine shall be a self-contained hydraulic fusion machine capable of butt fusing HDPE pipe. The carriage must be removable from the chassis for in-ditch use. The machine must be compatible with an electronic data recording device. Accessories will include all butt fusion inserts for the specified range of pipe sizes, a pyrometer kit for checking the surface temperature of the heater, extension cord (25' minimum), and hydraulic extension hoses (minimum of four). The butt fusion machine will be McElroy, or approved equivalent.

2. In areas where there may be insufficient space to layout the entire length of fused pipe to be pulled-back, the Contractor shall utilize a continuous HDPE pipe fusion equipment such as a PolyHorse by McElroy or other means in order to fuse the length of pipe necessary for the installation. The Contractor shall be responsible for securing and obtaining permission/permits from adjacent property if necessary, for staging and/or fusing of the pipe and HDD equipment at no additional cost to the Owner.

F. **Fusion Data Recording:**

1. For 6” and larger pipe sizes, McElroy Datalogger or equivalent fusion data recorder shall be used to record all fusion welds on hydraulically operated fusion machines. The device shall be capable of meeting the requirements of ASTM F 3124, “Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings”. The device, or combination of devices, shall record the following variables of each fused joint:

    a. Heater surface temperature immediately before inserting the heater plate. Alternatively, the heater plate may be measured with a pyrometer and entered into the weld record.
    b. Gauge pressure during the initial heat cycle.
    c. Gauge pressure and elapsed time during the heat-soak cycle.
    d. Heater removal (dwell) time.
    e. Gauge pressure and elapsed time during the fusing/cool cycle.
    f. Drag pressure.
    g. Pipe diameter and wall thickness.
    h. Type of HDPE material (Specification and Classification) and manufacturer.
    i. Fusion Machine Identification

2. The device shall record the operator, a unique operator ID number, the date and time of each weld.

3. Records showing the device is up to date on all required calibration should be available for presentation when requested.

4. All fusion welds should be traceable to the report (via operator and weld ID) with an indentation weld stamp or by permanent paint marker/pen next to fusion weld.

5. When requested prior to commencement of work, a weld location map may be requested by the Owner or Owner's representative.

G. **Butt Fusion Examination and Testing:**

1. Examinations

a. Visual
For pipe sections, examine the full exterior circumference for bead uniformity before cutting. After cutting the pipe section, review the interior bead. All beads should have visually acceptable bead formation as shown in Fig 4 and Appendix X2 of ASTM F 2620. In addition, the following characteristics are expected:

1) There shall be no evidence of cracks or incomplete fusing.
2) There shall be no evidence of captured objects (e.g., pipe shavings, facer ribbons) between bonded surfaces.
3) Variations in upset bead heights on opposite sides of the cleavage and around the circumference of fused pipe joints are acceptable.
4) The apex of the cleavage between the upset beads of the fused joint shall remain above the base material surface.
5) Fused joints shall not display visible angular misalignment, and outside diameter mismatch shall be less than 10% of the nominal wall thickness.
6) Fusion data record review that meet criteria of section 6-2.1 can be used as additional verification of visual indicators.

b. Fusion Data Record Review
The fusion date record for each fused joint shall be compared to the approved fusion procedure. The reviewer shall verify the following:

1) That all data required by section 6-1.1 was recorded
2) Interfacial pressure was within the acceptable range
3) Heater surface temperature was within the acceptable range
4) Butt fusion pressure applied during the fusing/cool cycle was correctly calculated to include drag pressure, fell within the acceptable range for the applicable size and agrees with the recorded hydraulic fusing pressure.
5) Butt fusing pressure was reduced to a value less than or equal to drag pressure at the beginning of the heat soak cycle.
6) Fusing machine was opened at the end of the heat soak cycle, the heater was removed, and the end were brought together at the fusion pressure with the acceptable time range
7) Cooling time at butt fusing pressure met the minimum time specified

c. If the recorded data in section 3.05.G.1.b is outside the limits of the acceptable range, the joint is unacceptable.

d. Frequency. Records for test fusion joints should be reviewed immediately after the joint is completed. Fusion joints for jobsite fusions should be reviewed daily or before being covered with backfill.

2. Mechanical Tests

   a. Contractor shall mechanically test the first fusion of each operator and each machine used on the project. Installation shall not continue until a fusion test has passed the test. Additional mechanical tests are not required as long as long as the fusion are reviewed with the frequency specified in section 3.05.G.1.d. Testing of fusion joints with no fusion data record review shall be at a frequency specified by the Owner or Engineer.

   b. The fusion shall be allowed to cool completely, then fusion test straps shall be cut out.

   c. All samples shall be labeled with operator information. Testing must be done at 73 degrees F plus or minus 5 degrees. The test temperature and sample size are critical to testing. Testing performed at cold or elevated temperatures may not give similar results to tests performed at ambient temperatures.

   d. Each pipe sample weld shall be subjected to testing at two locations 180 degrees apart from each other in the joint weld. All specimens shall be tested by the following method:

      1) Hydrostatic Burst Test is allowed for pipe sizes 2”-24”. The specimen length should measure 6 times pipe diameter with the butt fusion joint in the center of the specimen. The specimen should be tested in a tank filled with water, and testing conditions monitored and recorded with computerized equipment. The specimen will be tested at 4 times pipe rated pressure for 5 minutes with no failure of joint allowed.

   e. Results of any mechanical test should be documented. Information on the weld and operator should be transferred from the sample to the testing record.

3.06 TESTING AND LEAKAGE

B. All pumps, valves, temporary connections, meters, gauges and other measuring devices shall be furnished, installed and operated by the Contractor and all such equipment and devices and their installation shall be approved by the Owner's Engineer. The contractor shall restrain pipe, components, and test equipment as required to ensure testing can be accomplished in a safe manner, including protection of personnel, equipment, and public in the event of a failure during testing.

C. The pressure gauges or data recorders should be calibrated and sufficiently sized to provide mid-range data (pressure tested will not be below 10% or greater than 90% of gauge capacity) that result in easy reading, interpretation. Gauges shall be accurate to within 2% of full scale with increments no greater than 10 psi.

D. Gravity Pipelines

   1. The Contractor shall perform a low-pressure air test for gravity flow pipelines to the requirements and specifications of ASTM F 1417. Warning: All pneumatic test, regardless of pressure, can be dangerous and safety procedures shall be identified, documented, approved by the Owner and Engineer, and followed.

E. Pressure Pipelines

1. Pressure testing shall be conducted in accordance with requirements and recommendations of ASTM F 2164 (Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure), AWWA Manual of Practice M55 Chapter 9, and PPI Handbook of Polyethylene Pipe Chapter 2 (2nd Edition). Pneumatic (compressed air) leakage testing of HDPE pressure piping is prohibited for safety reasons.
2. The section of pipe to be tested shall be filled with potable or generally clean water (uncontaminated river/lake water) approved by the Owner/Engineer. While the system is being filled with water, air shall be carefully and completely exhausted. If permanent air vents are not located at all high points, the Contractor shall install fittings and valves at such points so the air can be expelled as the pipe system is slowly filled with water.
3. If the Contractor elects to perform hydrostatic testing against valves in an existing distribution system, it does so at his own risk and will bear the cost of any damages to the existing valve, piping system, private or public property, or the new pipeline under test.
4. The test procedure for HDPE pipe consists of two steps: 1) the initial phase or expansion phase and 2) the test phase. During the initial/expansion phase, sufficient make-up water shall be added hourly for 3 hours to return to the test pressure. During the test phase, the expansion phase pressure is reduced by 10 psi to test phase pressure and monitored for at least one hour (3 hours maximum).
5. Under no circumstances shall the total time under test exceed eight (8) hours. If the test is not completed due to leakage, equipment failure or any other reason, depressurize the test section and permit the system to "relax" for eight (8) hours prior to the next testing sequence.
6. The test pressure should be related to the lowest point in elevation along the test section's vertical pipeline profile.
7. All pressure and leakage testing shall be done in the presence of a representative of the Owner and Engineer.
8. The test pressure shall be 1.5 times the operating pressure at the lowest point in the system. In accordance with section 9.8 of ASTM F 2164, the pipe shall pass if the final pressure is within 5% of the test phase pressure for the testing period (3 hours maximum). If the test section fails this test, the Contractor shall repair or replace all defective materials and/or workmanship at no additional cost to the Owner.

3.07 MARINE/RIPARIAN PIPELINE INSTALLATION

A. GENERAL

1. Refer to Attachment 2: Chapter 10 Marine Installations of polyethylene pipelines for installation methods in marine and riparian areas.

END OF SECTION

SECTION 02670
HYDROSTATIC TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section consists of testing of water main and related appurtenances.

1.02 REFERENCES

A. AWWA C-600: Installation of Ductile-Iron Mains and Their Appurtenances.

B. AWWA C-605: Underground Installation of Polyvinyl Chloride (PVC) and Molecularly-Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.

PART 2 PRODUCTS- NOT USED

PART 3 EXECUTION

3.01 HYDROSTATIC TESTING – DIP, PVC, & PVCO

A. Perform hydrostatic testing in accordance with AWWA C600 (Installation of Ductile-Iron Mains and Their Appurtenances) or AWWA C605 (Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings), as appropriate.

B. Pressure Test: After pipe has been laid, subject all pipe or any valved section thereof to a hydrostatic pressure test.

1. Test Pressure Restrictions:
    a. The test pressure should be not less than 1.25 times the stated anticipated maximum sustained working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the sustained working pressure at the lowest elevation of the test section.
    b. Not exceed pipe or thrust restraint design pressures or pipe pressure class.
    c. Not exceed twice the rated pressure of valve or hydrants when they form the boundary of the test section.
    d. Not exceed the rated pressure of gate valves when they form boundary of test section.
2. Air Removal:
    a. Before applying test pressure, expel all air from test section.
    b. If permanent air vents are not located at all high points, install corporation stops to vent the air.
3. Pressurization:
    a. Slowly fill each valved section of pipe with water.

b. Bring to the required test pressure, based on the elevation of the highest point in the test section, corrected to the elevation of the test gage using a suitable pressure pump.

c. Examine all exposed pipe, fittings, valves, hydrants, and joints and correct any visible leakage.

d. Continue pressure test for minimum of two (2) hours. Pressure test passes if pressure can be maintained sufficiently to complete leakage test.

e. If test fails, Contractor to make necessary repairs and retest at no cost to Owner. Contractor to perform retests and take corrective actions as required until a "passing" test is achieved.

C. Leakage Test:

1. Conduct concurrently with pressure test.

2. Leakage Defined: The quantity of water that must be supplied to a valved section of pipe to maintain pressure within five (5) psi of specified test pressure.

3. Allowable Leakage not to exceed that determined by the following formula:

$$L = \frac{S * D * P^{0.5}}{148{,}000}$$

L = Allowable leakage, in gallons per hour

S = Length of pipeline tested, in feet

D = Nominal pipe diameter, in inches

P = Average test pressure, in pounds per square inch (psi) gage

4. Re-pressure line as often as needed to maintain pressure within five (5) psi of specified test pressure.

5. Accumulative total water used to re-pressure line is compared to allowable leakage calculated to determine success of test.

D. If hydrostatic testing will result in a discharge of water from the system, the Contractor will be required to secure coverage under a Temporary Discharge Permit from DEQ. For additional information, refer to Specification Section 01041.

3.02 HYDROSTATIC TESTING - POLYETHYLENE PIPE

A. Perform hydrostatic testing of polyethylene pipe in accordance with relevant AWWA standards.

B. Bleed off any trapped air and then raise the hydrostatic pressure to a pressure that is 1.5 times the system maximum working pressure at the highest elevation in the test section. Do not exceed the rated pressure of gate valves when they form boundary of test section.

C. To compensate for initial expansion of the pipe under test, add sufficient makeup water to the system at hourly intervals for three (3) hours to return to the test pressure.

D. Four (4) hours after initial pressurization, begin actual pressure test. Run test for three (3) hours.

E. Re-pressure line as often as needed to maintain pressure within five (5) psi of specified test pressure. If the amount of makeup water exceeds that amount as determined by the following formula, plus the allowance for expansion, the test failed.

$$L = \frac{S * D * P^{0.5}}{148{,}000}$$

L = Allowable leakage, in gallons per hour

S = Length of pipeline tested, in feet

D = Nominal pipe diameter, in inches

P = Average test pressure, in pounds per square inch (psi) gage

F. If test fails, Contractor to make necessary repairs and retest at no cost to Owner. Contractor to perform retests and take corrective actions as required until a “passing” test is achieved.

G. Allowance for expansion, U.S. Gallons/100 feet of pipe.

Nominal Pipe Dia. Inches	1-Hour Test	2-Hour Test	3-Hour Test
2	0.05	0.10	0.15
3	0.10	0.15	0.20
4	0.13	0.25	0.40
6	0.30	0.60	0.90
8	0.50	1.00	1.50
10	0.70	1.30	2.10
12	1.10	2.30	3.40
14	1.40	2.70	4.20

If the test is not completed in 8 hours, allow the test section to "relax" for eight (8) hours before retesting.

PART 4 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

4.01 METHOD OF MEASUREMENT

A. Unless otherwise noted in the special provisions, no separate measurement will be made for items under this section. Full compensation shall be considered as included in the prices paid for the various contract items and no additional compensation will be allowed therefor.

4.02 BASIS OF PAYMENT

A. Unless otherwise noted in the special provisions, no separate payment will be made for items under this section. Full compensation shall be considered as included in the prices paid for the various contract items and no additional compensation will be allowed therefor.

END OF SECTION

SECTION 02910
SEEDING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes ground surface preparation; furnishing and applying fertilizer; and furnishing and planting seed in areas described in the contract documents or directed by the Engineer.

B. Hydraulic seeding is not included in this section. Hydraulic seeding is covered in Section 02920, Hydraulic Seeding.

1.02 SUBMITTALS

A. Submit to the Owner and Engineer applicable seed mixture certifications, fertilizer descriptions and mulch certifications. Furnish duplicate signed copies of the vendors statement certifying that each seed lot has been tested by a recognized seed testing laboratory within 6 months of date of delivery. Assure the statement includes: Name and address of laboratory, date of test, lot number for each seed species and the test results including name, percentages of purity and of germination, percentage of weed content for each kind of seed furnished and, for seed mixes, the proportions of each kind of seed.

PART 2 PRODUCTS

2.01 SEED

A. Coordinate with Owner to determine the seed mix requirements for the project.

B. Furnish seed and seed mixture, free of all prohibited noxious weed seed or any other weed seed prohibited by state or local ordinance.

C. Seal and label all seed containers to comply with Montana Seed Law and Regulations or meeting U.S. Department of Agriculture and Regulations under the Federal Seed Act, if shipped in interstate commerce.

D. Do not use wet, moldy, or otherwise damaged seed in the work.

E. Furnish seed mixture of the species described in the contract documents. Furnish seed in standard containers labeled with the seed name, lot number, net weight, percentages of purity, germination, hard seed, and percentage of maximum weed seed content for each seed species.

2.02 TOPSOIL

A. Use topsoil that is loose, friable, loamy soil, free of excess acid and alkali. Assure topsoil does not contain objectionable amounts of sod, hard lumps, gravel, sub-soil or other undesirable material that would form a poor seedbed. Before striping topsoil, assure it has supported the growth of healthy crops, grass or other vegetable growth.

2.03 LIME

A. Furnish ground limestone or other material deemed suitable by the Engineer containing a minimum 85 percent of total carbonate equivalent ground so that 90 percent will pass through a No. 100 mesh sieve. Coarser material may be acceptable, if the application rates are increased to provide at least the minimum quantities and depth specified using an approved Dolomitic lime or a high magnesium lime containing at least 10 percent magnesium oxide.

2.04 FERTILIZER

A. Furnish standard commercial fertilizers supplied separately or in mixtures containing the specified percentages of total nitrogen, available phosphoric acid, and water soluble potash. Apply fertilizer at the specified rate and depth meeting the applicable State and Federal laws. Furnish fertilizer in standard containers clearly labeled with name, weight, and guaranteed analysis of contents. No cyanamide compounds of hydrated lime are permitted in mixed fertilizers.

B. Fertilizers may be supplied in one of the following forms:

1. A dry, free-flowing fertilizer suitable for application by a common fertilizer spreader;
2. A finely-ground fertilizer soluble in water, suitable for application by power sprayers; or
3. A granular or pellet form suitable for application by blower equipment.

2.05 SOILS FOR REPAIRS

A. Use soil for filling and top soiling repair areas of equal quality to the existing topsoil being repaired. Assure the soil is free of large stones, roots, stumps, or other materials that interfere with sowing, compacting, and establishing turf. Obtain approval from the Engineer before placing topsoil.

PART 3 EXECUTION

3.01 TOPSOIL

A. Place at least 6 inches (15 cm) of topsoil in all areas to be seeded. Import topsoil if sufficient topsoil is not available from excavated areas of the project.

3.02 ALLOWABLE SEEDING MONTHS

A. Perform seeding when the temperature and moisture are favorable to germination and plant growth. Seed preferably before June 1st and after October 1st of each year. Seeding dates must be approved by the Engineer.

3.03 SEEDBED PREPARATION AND SOWING

A. Clear the areas to be seeded of all debris, vegetation, and other material determined by the Engineer to be detrimental to the preparation of a seedbed. Once the area is cleared, disc, harrow, rake, or work the area by other suitable methods, into a smooth, even seedbed. Assure the prepared seedbed surface is firm enough to prevent seed loss from high winds or normal rainfall. If rolling is required, perform rolling before seeding using a suitable roller, of a weight appropriate to the soil conditions.

B. Sow seed in the areas described in the contract documents at the specified application rates.

C. Sow seed using a force feed drill having a grass seed attachment, except of slopes steeper than three to one or on areas too small to be seeded with a force feed drill. In these areas, seed may be sown by power sprayers, blowers or other effective methods. Use equipment in good working order.

D. Seed Kentucky Bluegrass at a depth of one-quarter inch or less and cultipack the seed.

E. Do not sow seed in winds that prevent proper imbedment into the surface.

3.04 FERTILIZER

A. A. Spread and work fertilizer into the soil during the final seedbed preparation. Apply fertilizer at the rate described in the contract documents.

3.05 CARE OF SEEDED AREAS

A. Keep the seeded area moist until it has germinated and it's continued growth is assured. Prevent erosion during watering. Water is incidental to the item "Seeding".

B. Protect all seeded areas from traffic or pedestrian use with warning barricades or other Engineer approved methods.

C. Maintain the seeded area, performing any required watering and mowing until the seed is firmly established. Prevent weeds and other undesirable vegetation from establishing in the seeded area. Mow weeds and rake and remove the clippings from the areas.

D. Replace any seeded areas failing to germinate which have died or been damaged by construction activities. Replace such areas to meet the contract requirements. The contract warranty period applies to this item.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Seeding is measured by the square yard (square meter) and paid for at the unit price bid including topsoil salvage and/or importing, topsoil placement, seedbed preparation, and seeding, complete in place and accepted by the Engineer.

B. Payment indicated to include complete compensation for all labor, equipment, materials and incidentals required for the completion of the work.

END OF SECTION

SECTION 02920
HYDRAULIC SEEDING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes the hydraulic seeding of the areas shown on the contract documents or as directed by the Engineer. Hydraulic seeding is typically employed for slopes steeper than 3:1 (horizontal to vertical) or when the seedbed surface is impractical to drill seed.

PART 2 PRODUCTS

2.01 PRODUCTS ARE AS DESCRIBED IN SECTION 02910, SEEDING, PART 2, PRODUCTS.

PART 3 EXECUTION

3.01 TOPSOIL

A. Place at least 6 inches (15 cm) of topsoil in all areas to be seeded. Import topsoil if sufficient topsoil is not available from excavated areas.

3.02 APPLICATION RATES

A. Apply seed mixture to the areas described in the contract documents at the specified application rates.

3.03 MAINTENANCE RESPONSIBILITIES

A. A. Maintain and protect newly seeded areas until the grass is established and accepted by the Engineer. During this period, repair damaged areas and reseed areas where complete establishment has not occurred.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

A. Hydraulic seeding is measured and paid for by the square yard (square meter) and paid for at the unit price bid including topsoil salvage and/or importing, topsoil placement, seedbed preparation, fertilizer, mulch and seed, complete and in place and accepted by the Engineer.

B. Payment indicated to include complete compensation for all labor, equipment, materials and incidentals required for the completion of the work.

END OF SECTION

DIVISION 3
CONCRETE

SECTION 03210
REINFORCING STEEL

PART 1 GENERAL

1.01 DESCRIPTION

A. This work is furnishing and placing reinforcing steel or wire fabric meeting the quality, type and size specified in the contract.

1.02 REFERENCES

1. ASTM A-615
2. ASTM A-705
3. AASHTO M 31 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
4. AASHTO M 32 Cold Drawn Steel Wire for Concrete Reinforcement
5. AASHTO M 55 Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement
6. AASHTO M 54 Fabric Deformed Steel Bar or Rod Mats for Concrete Reinforcement

PART 2 PRODUCTS

2.01 FURNISH ALL NEW MATERIAL MEETING THE FOLLOWING REQUIREMENTS.

A. Bar Reinforcement

1. Furnish deformed reinforcement steel meeting ASTM A 615, (AASHTO M3 1) or ASTM A705, Grade 40 or Grade 60.

    a. a. Small quantities purchased from warehouses may, at the Engineer's direction, be accepted if bend tested under ASTM A615 or AASHTO M31. The test specimen must cold bend around a pin without cracking on the outside of the bent portion.

B. Wire and Wire Mesh

1. Furnish wire meeting cold-drawn steel wire AASHTO M32 (ASTM A82) requirements.
2. Furnish wire mesh for concrete reinforcement meeting AASHTO M 55 (ASTMA A 185).
3. Furnish bar mats meeting AASHTO M54 (ASTM A 184).

PART 3 EXECUTION

3.01 PROTECTION

A. Protect steel reinforcement from damage at all times. Place steel free from dirt, detrimental scale, paint, oil and other foreign substance. Clean steel reinforcement having easily removed rust, loose scale, and dust using an approved method.

3.02 FABRICATION

A. Furnish four copies of shop details and placing drawings for all reinforcing steel to the Engineer for approval. Once checked, the Engineer will return two markedup sets of prints or drawings for correction. The Engineer's review is only for general conformity with the plans. Checking the detailed dimensions is the Contractor's responsibility. The Engineer's review does not relieve the Contractor's responsibility to furnish all material meeting the Contract requirements. Detail Reinforcing, steel meeting the ACI "Standard Details and Detailing of Concrete Structures" and the "Manual of Engineering and Placing Drawings for Reinforced Concrete Structures" published by the American Concrete Institute (ACI 315).

B. Assure all bars are bent cold. Do not field bend any bar partially imbedded in concrete except as specified on the plans.

C. Ship bar reinforcement in standard bundles, tagged and marked meeting the "Details and Detailing of Concrete Structures" (ACI 315) requirements.

D. Concrete reinforcement and accessory details, not covered herein or on the drawings, must meet "Details and Detailing of Concrete Structures" and the "Manual of Engineering and Placing Drawings for Reinforced Concrete Structures" (ACI 315 and 315R) requirements.

3.03 PLACING AND FASTENING

A. Accurately place and hold firm all steel reinforcement in the plan locations as concrete is being placed.

B. Support and fasten together all reinforcement to prevent displacement due to construction loads. It is permissible to use on ground, where necessary, concrete support blocks having a minimum 4 square inches (2580 MM2) bearing area and having a compressive strength equal to the concrete being placed. Use approved bar chairs and spacers over form work. For concrete surfaces exposed to the weather in the finished structure, assure the portions of all accessories within ½- inch (12.7 mm) of the concrete surface are noncorrosive or protected against corrosion.

C. Overlap welded wire fabric for successive mats or rolls providing an overlap measured between outermost cross wires of each fabric sheet at least 2 inches (50.8 mm). Extend the fabric across supporting beams and walls to within 4 inches (101.6 mm) of concrete edges. It may extend through contraction joints. Adequately support the fabric during concrete placement to maintain its position in the slab using the methods previously described or by laying the fabric on a concrete layer of the required depth before placing the upper slab layer.

D. Offset vertical bars in columns at least one bar diameter at lap splices. Furnish templates for all column dowels.

E. Obtain Engineer approval for all splices not shown on the plans. Mechanical connectors for reinforcing bars may be used if approved.

F. Do not use pebbles, pieces of broken stone, concrete rubble, broken brick or building blocks, metal pipe, or wooden block to position the fabric.

G. Follow the minimum concrete protective covering for reinforcement below.

1. Concrete deposited against ground: 76.2 mm (3 inches)
2. Formed surfaces exposed to weather or in contact with the ground:
   a. #6 bars or larger 50.8 mm (2 inches)
   b. Smaller than #6 bars 38.1 mm (1-1/2 inches)
3. Interior Surfaces:
   a. Beams, girders and columns 38.1 mm (1-1/2 inches)
   b. Slabs, walls and joists:
      1) #11 bars or smaller 19.05 mm (3/4-inch)
      2) #14 and #18 bars 38.1 mm (1-1/2 inches)

H. For corrosive atmospheres or fire protection, see special provisions for minimum covering requirements.

I. Obtain Engineer approval of reinforcement placement before placing concrete. Remove and replace concrete placed without Engineer approval of reinforcing.

J. Straighten fabric reinforcement shipped in rolls into flat sheets before placing it.

3.04 WELDING

A. When specified or approved, weld reinforcing steel meeting “Reinforcing Steel Welding Code” (AWSD 1 –4). Do not weld at bends in bars. Do not tack weld crossbars without Engineer approval.

PART 4 MEASUREMENT AND PAYMENT

4.1 GENERAL

A. A. Reinforcing steel used in the work is not measured. The cost of furnishing and placing reinforcing steel is incidental and included in the unit price or lump sum price bid for various items of the work.

END OF SECTION

SECTION 03310
STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish structural concrete meeting all specified requirements that is composed of Portland cement, aggregates, water. Furnish Ready-mixed concrete meeting ASTM C94 unless otherwise specified.

1.02 REFERENCES

1. ASTM C-94 Standard Specification for Ready-Mixed Concrete
2. ASTM C-150 Specification for Portland Cement
3. ASTM C-618 Specification for Coal Flyash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
4. ASTM C-989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
5. ASTM C-595 Specification for Blended Hydraulic Cements
6. ASTM C-157 Performance Specification for Hydraulic Cements
7. ASTM C-33 Specification for Concrete Aggregates
8. ASTM C-260 Specification for Air-Entraining Admixtures for Concrete
9. ASTM C-494 Specification for Chemical Admixtures for Concrete
10. ASTM C-1017 Specification for Chemical Admixtures for Use in producing Flowing Concrete
11. ASTM D-98
12. ASTM C-138 Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
13. ASTM C-173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
14. ASTM C-231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
15. ASTM C-31 Practice for Making and Curing Concrete Test Specimens in the Field
16. ASTM C-39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
17. ASTM C-172 Practice for Sampling Freshly Mixed Concrete
18. ACI 301 Standard Specification for Structural Concrete for Buildings
19. ACI 305 Hot Weather Concrete

20. ACI 306 Cold Weather Concrete

21. ACI 318 Building Code Requirements for Reinforced Concrete

1.03 QUALITY ASSURANCE

A. Codes and Standards: The codes and standards referred to in this section are declared to be part of this specification as if fully set forth herein. In addition, the following ACI Standards are incorporated in their entirety, unless specifically required otherwise:

1. ACI Standard 301, "Specifications for Structural Concrete for Buildings," American Concrete Institute, Edition.
2. ACI Standard 318, "Building Code Requirements for Reinforced Concrete", American Concrete Institute, current edition.
3. Concrete Reinforcing Steel Institute, "Manual of Standard Practice".
4. International Building Code of I.C.B.O.

B. Concrete Testing: The Contractor shall employ at his expense a testing laboratory acceptable to the Engineer to perform material evaluation tests and/or perform the mix design prior to placing any concrete. The Engineer will perform all acceptance testing during the onsite placement of the concrete. Retesting or additional testing of concrete or materials failing to meet the requirements of these specifications shall be done by the Contractor at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 CLASSIFICATION

A. Concrete is classified as set forth below. Place the specified class of concrete for each structure element as specified. Concrete with prefixes "C" contain 1-1/2 inch (38.1 mm) size aggregate and those with "M" contain 3/4 inch (19.05 mm) size aggregate. Concrete with prefixes "M" may be substituted for concrete with prefixes "C."

1. Use M-4000 concrete for curb and gutter, sidewalks, driveways, approaches, curb turn fillets and valley gutters and structural concrete.
2. Use M-3000 concrete for manholes, storm drain inlets and miscellaneous or C-3000 Concrete Construction class.
3. M-3000 is concrete with 3/4 inch (19-05 mm) maximum aggregate and a 28-day compressive strength of 3000 pounds per square inch (psi) (20.7 Mpa).
4. M-4000 is concrete with 3/4 inch (19-05 mm) maximum aggregate and a 28-day compressive strength of 4000 pounds per square inch (psi) (27.6 Mpa).
5. C-3000 is concrete with 1-1/2 inch (38.1 mm) maximum aggregate and a 28-day compressive strength of 3000 psi (20.7 Mpa).

B. If concrete strength or durability requirements established by design exceed the above strength classifications, the Engineer may specify additional concrete classifications to meet those requirements.

1. EXECUTION

2.02 COMPOSITION OF CONCRETE

A. Upon receipt of the notice of award of the contract, furnish the Engineer with names of suppliers and locations of sources of materials proposed for use.

1. Materials

a. Cementitious Material: Cementitious material consists of Portland cement meeting ASTM C 150, with or without the addition of cementitious or pozzolanic mineral admixtures meeting, ASTM C618 or ASTM C989, or blended hydraulic cement meeting ASTM C595 or hydraulic cement meetingASTM 1157. Unless otherwise specified, assure cementitious material meets ASTM C 150 Type I or Type II. Assure cementitious material used in concrete is the same brand and type and from the same plant of manufacture as the cementitious material used in the concrete represented by the submitted field test date or used in the trial mixtures.

b. Aggregates: Assure aggregates meet ASTM C33. When a single size or a combination of two or more sizes of coarse aggregates are used, assure the final gradation meets the grading requirements of ASTM C33. Obtain concrete aggregates from the same source and use the same size ranges as the aggregates used in the concrete represented by submitted historical data or used in trial mixtures.

c. Water and Ice: Use concrete mixing water and water to make ice meeting requirements of ASTM C94.

d. Admixtures: Use admixtures meeting the following requirements:

1) Air entraining, admixtures - ASTM C260
2) Chemical admixtures- ASTM C494
3) Chemical admixtures for use in producing, flowing concrete- ASTM C1017
4) Calcium Chloride - ASTM D98
5) Use admixtures in the concrete that are the same as those used in the concrete represented by submitted field test data or in trial mixtures.

2. Change of materials

a. a. When brand, type, size, or source of cementitious materials, aggregates, water, ice or admixtures are requested to be changed, submit new field data or data from new trial mixtures or furnish evidence that indicates that the change will not adversely affect the relevant properties of the concrete for acceptance before using the concrete.

B. Performance and Design Requirements

1. Assure the cementitious material content is adequate to meet the specified requirements for strength, water-cement ratio and finishing requirements. For concrete used in floors, assure the cement content is at least that indicated in Table 2.1. For concrete exposed to freezing and thawing or concrete exposed to deicers, assure a maximum water-cement ration of 0.45.

TABLE 2.1
MINIMUM CEMENT CONTENT REQUIREMENTS

Nominal Maximum size of aggregate, in(mm)	Minimum cement content lb/yd3 (kg/m3)
1-1/2 (38-1)	470* (163.0)
1 (25.4)	520 (180.3)
3/4 (19-05)	540 (187-3)
3/8 (9-5)	641 (222.3)

* Minimum cement content is 520 lb/yd^3 (180.3 kc,/m^3) and maximum H2O/cement ratio of 0.45 if concrete will be exposed to freezing and thawing and/or in the presence of deicing chemicals.

2. Furnish concrete at the point of delivery having a slump of 4 inches (max) (100 mm) determined by ASTM C 143. Meet slump tolerances in ACI 117. When a plasticizing admixture is used meeting ASTM C 10 17 or when a Type F or G high range water reducing admixture meeting ASTM C494 is approved to increase the concrete slump, assure the concrete has a slump of 2 to 4 inches (50-100mm) before the admixture is added and a maximum slump of 8 inches (200 mm) at the point of delivery after the admixture is added.

3. Assure the nominal maximum size of coarse aggregate does not exceed three fourths of the minimum clear spacing between reinforcing bars, one fifth of the narrowest dimension between sided of forms or one-third of the thickness of slabs or toppings.

4. Concrete must be air entrained. Measure air content under ASTM C 138, C 173 or C231. Unless otherwise specified, ASTM C231 shall be used.

TABLE 2.2
TOTAL AIR CONTENT* OF CONCRETE
FOR VARIOUS SIZES OF COARSE AGGREGATE

Nominal maximum Size of aggregate mm, (in.)	Total air content, percent		
	Severe exposure	Moderate exposure	Mild exposure
Less than 9.53(3/8)	9	7	8
9.53 (3/8)	7.5	6	4.5
12.5(1/2)	7	5.5	4
19 (3/4)	6	5	3.5
25.4(l)	6	4.5	3
12.7(1-1/2)	5.5	4.5	3
50.8(2)	5	3.5	1.5
76.2(3)	4.5	3.5	1.5
152.4(6)	4	3	1

* Measure in accordance with ASTM C 138, C 173, or C 231. Air content tolerance is +/- 1 1/2 percent

a. When admixtures are specified in the Contract documents for particular parts of the work, use types specified. Use of calcium chloride or other admixtures containing chloride ions is subject to the limitations in Table 2.3 Chloride Ion Concentration. When approved, use calcium chloride in solution form only, when introduced into the mixture.

1) Assure the maximum water soluble chloride ion concentrations in hardened concrete at ages from 28 to 42 days attributed to the ingredients including water, aggregates, cementitious materials and admixtures do not exceed the limits of Table 2.3. Use tests to determine water soluble chloride ion content meeting AASHTO T260. The type of member described in Table 2.3 applies to the work as indicated in the Contract Documents.

TABLE 2.3
MAXIMUM ALLOWABLE CHLORIDE ION CONTENT

Type of Member	Maximum water soluble chloride (CI) Content in concrete, percent by weight of cement
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	.30

b. When the average of the highest and lowest temperature during the period from midnight to midnight is expected to drop below 40°F (40°C) for more than three successive days, deliver concrete in accordance with ASTM C-94.

c. Furnish the compressive strength and the water-cement or water cementitious, material ratio of concrete for each portion of the work as specified in the Contract documents.

1) If cementitious or pozzolanic mineral admixtures meeting, ASTM C618 or ASTM C989 are used, the cement portion of the water-cement ratio must be the total weight of cementitious material.
2) The maximum weight of fly ash, pozzolan or ground granulated blast-furnace slag included in the calculation of water-cementitious material ratio cannot exceed the following percentages of the total weight of Portland cement plus fly ash, pozzolan and ground granulated blast furnace slag:
3) The combined weight of fly ash and pozzolan meeting ASTM C618 cannot exceed limits in ACI 318. The fly ash and pozzolan present in an ASTM Type IP or IPM blended cement meeting ASTM C595 must be included in the calculated percentage.
4) The weight of ground granulated blast-furnace slag meeting ASTM C989 cannot exceed 50 percent of the total weight of cementitious material. The slag used in manufacture of a Type IS or ISM blended hydraulic cement meeting ASTM C595 must be included in the calculated percentage.
5) If fly ash or pozzolan is used in concrete with ground granulated blast-furnace slag, the Portland cement constituent meeting ASTM C 150 cannot be less than 50 percent of the total weight of cementitious material. Fly ash or pozzolan must not constitute more than 25 percent of the total weight of cementitious material.
6) Strength requirements are based on the 28-day compressive strength determined on 6" x 12" (150mm x 300mm) cylindrical specimens made and tested under ASTM C31 and C39 respectively.

2.03 PROPORTIONING AND DESIGN OF MIXES

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method used, use an independent testing facility acceptable to the Engineer for preparing and reporting proposed mix designs.

B. Submit written reports of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed and approved.

PART 3 EXECUTION

3.01 CONCRETE MIXES

A. Job-Site Mixing: Mix materials for concrete in appropriate drum type batch match mixer. For mixers of one cu. Yd., or small capacity, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released. For mixers of capacity larger than

one cu. Yd., increase minimum 1-1/2 minutes of mixing time by 2.5 minutes for each additional cu. yd., or fraction thereof.

B. Provide batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mix type, mix time, batch quantities and amount of water introduced.

C. Ready-Mix Concrete: Comply with requirements of ASTM C94, and as herein specified.

D. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ANSI/ASTM C94 may be required.

E. When air temperature is between 85°F (30°C) and 90°F (32°C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90°F (32°C), reduce mixing and delivery time to 60 minutes.

3.02 CONSISTENCY

A. A. Assure concrete is of such consistency that it will flow around reinforcing steel, but individual particles of the coarse aggregate, when isolated, show a coating of mortar containing its proportionate quantity of sand. The consistency of the concrete will be gauged by the ability of the equipment to properly place the concrete in its final position and not by the difficulty in mixing or transporting. Use the minimum quantity of mixing water necessary to provide workability within the ranges of slump specified.

3.03 MIXING

A. Thoroughly mix concrete to assure a uniform distribution of the materials throughout the mass. Mix concrete only in quantities required for immediate use and place it within the time limits specified. Waste all concrete which initial set has begun. Retempering of concrete is prohibited. Aggregates, or bags of cement containing lumps or crusts of hardened material shall not be used. Mix concrete in an approved truck mixer meeting the requirements of ASTM C94 herein.

B. The capacity of the plant and the transportation equipment must ensure delivery at a rate that will permit proper handling, placement and finishing at the point of delivery. Maintain the concrete delivery rate to provide for the continuous operation of placing, handling and finishing concrete as is practical. Maintain the interval between delivery of loads so that layers or lifts of concrete in place do not harden before succeeding layers or lifts are placed. In general, no lift or layer of concrete can remain exposed for more than 20 minutes before being covered by fresh concrete.

C. The volume of mixed concrete in the mixing drum shall not exceed the manufacturer's rating, on the capacity plate.

D. During freezing weather, other approved methods of measuring water will be permitted.

E. A recording water metering device is always required at the primary point of the batching operation.

F. Do not add water to concrete in transit. Water may be introduced into the mixer at the job site under direction of the Engineer, if the specified water-cement ratio is not exceeded. Water must be added in accordance with ASTM C94, Assure the drum revolves continuously after the introduction of the cement and water until the concrete is discharged.

G. Begin mixing immediately after introduction of the cement and water and continue for at least 70 revolutions of the drum at mixing speed. This minimum revolution count will be waived when the concrete is produced at a central mixing plant. Not more than 100 drum revolutions can exceed 6 revolutions per minute. All other revolutions must be at agitating speed of not less than 2 or more than 6 revolutions per minute.

H. Discharge the concrete at the job and place in its final position within 1- 1/2 hours after the introduction of the mixing water and cement. When the air temperature is 90°F (30°C) or above, place the concrete in its final position within 1 hour after the introduction of the mixing, water and cement. Concrete mixes with an approved set retarding admixture may be held an additional ½ hour beyond limits specified above.

I. No mixed or agitated concrete that has remained in the drum of the truck mixer more than 10 minutes without agitation can be used. If the Engineer determines the concrete has not suffered any detrimental effects. It may be used, after remixing for a minimum of 20 revolutions of the drum at mixing speed, if it can still be placed in the forms within the specified time limits.

J. Provide a revolution counter on each truck that registers the number of revolutions of the drum.

K. Mount the counter so it can be easily read by both the operator and the Engineer.

3.04 PLACING CONCRETE

A. A. Thoroughly compact concrete into its final position. Assure it is thoroughly consolidated around fittings and embedded items. Assure all reinforcement and embedded items are accurately placed as shown on the plans and are clean and free from coatings of dried mortar, detrimental rust, scale, oil or foreign matter. Place concrete meeting the applicable requirements of Sections 02528 and 02529.

3.05 CURING CONCRETE

A. A. Thoroughly cure concrete surfaces subject to premature drying by covering as soon as possible with canvas, plastic sheets with sealed joints, burlap and sand or other satisfactory materials and keep concrete moist. If the concrete surfaces are not covered, keep them moist by flushing or sprinkling. Continue curing for at least 7 days after placing the concrete. Concrete surfaces placed against forms may be cured by leaving the forms in place for at least 7 days, when approved.

B. Protect concrete against freezing or other conditions detrimental to strength development meeting the applicable requirements of this specification.

C. To aid finishing, side forms on ornamental work, curbs and sidewalks, railing and parapets may be removed after 12 hours, not to exceed 48 hours, depending on weather conditions. Continue moist curing during the concrete finishing operation.

D. Untreated forms and existing concrete must be kept continuously wet for at least 1 hour before any concrete is placed. Keep wet until covered with concrete except that adequately treated forms must be thoroughly washed with a water spray immediately before placing the concrete.

E. The curing of concrete, by either water curing or membrane curing, must be as follows unless otherwise approved by the Engineer.

1. Water Curing

a. a. Keep all concrete top surfaces continuously moist after finishing, with a fine water spray, until the concrete has set. Cover the moist concrete with water or an approved curing covering.

b. Cure concrete deck slabs and concrete floors for at least 7 days. Cure by placing burlap, cotton mats or other absorptive material as close behind the finishing operation as possible without marring the finished surface. Keep the absorptive material continuously moist for the full time it is used. The absorptive material may be kept in place for the entire curing period or it may be removed as soon as practical and the entire surface covered with approximately 1-1/2 inches (38.1 mm) of sand, kept continuously moist for the entire curing period.

c. Remove forms and repair surface irregularities without interfering with any of the curing requirements. As soon as the vertical forms have been removed and the surface irregularities repaired, cover the concrete with absorptive material, kept continuously wet for the balance of the curing a period.

2. Impervious Membrane Curing

a. Assure membrane curing compounds are delivered to the job in the manufacturer’s original container, clearly labeled to show the name of the manufacturer and the contents. The clear curing compound must be sufficiently transparent and free from permanent color that would change the color of the natural concrete. Use clear compound containing a fugitive dye having color sufficient to render the film visible on the concrete for at least 4 hours after application. The concrete surface must maintain its natural color after curing.

b. Use a compound ready for use as shipped by the manufacturer. Dilute following the manufacturer's recommendations. Use curing compound only with written approval. Sampling will not be required if manufacturer's certification is available. Apply the curing compound under pressure with a spray nozzle to cover the entire exposed surface thoroughly and completely with a uniform film not exceeding manufacturer's specifications. Maintain the required pressure in the spray machine to force the material to leave the nozzle in a fine mist. Keep all concrete surfaces moist with a fine water spray or with wetted burlap until the sealing compound is applied. Keep the curing compound application close to the finishers of the top surface of concrete at all times. Seal the concrete immediately after the finishing operations have been completed, to the satisfaction of the Engineer.

c. If it is necessary to allow workers or equipment on the surface before the 7 day curing period is completed, cover the top surface of sealed concrete with a protective cushion for runways.

Use a cushion consisting of a moist, 1 –inch (25mm) minimum thick layer of fine sand, or layers of moist burlap that will prevent damage to the finished concrete. Cover the approved cushion with four by eight-foot sheets of 3/4 inch(19mm) plywood laid over the cushion. Do not place the cushion material for at least 8 hours after the final application of the curing compound. Obtain the Engineer's written approval for any other proposed cushion material before use. Layers of plastic, visqueen or canvas are not an acceptable cushion material.

d. Keep concrete, which has not completed its curing period, continuously moist during the stripping and surface repair operations. Remove all surface irregularities, repair all depressions, voids or holes, including those formed by trapped air, to the satisfaction of the Engineer. Immediately apply the curing compound before the surface has had an opportunity to dry out. Keep concrete, from which forms have been stripped, continuously moist until surface repair and finishing are completed and the impervious membrane curing has been applied.

3.06 WEATHER AND NIGHT LIMITATIONS

A. General

1. 1. Stop concreting operations when darkness prevents obtaining the specified placing and finishing work. Night operations may be conducted with written approval and when approved artificial lighting is provided.
2. Cold weather concreting is governed by ACI 306 unless otherwise specified herein. Hot weather concreting methods is governed by ACI 305 unless otherwise specified herein. Except by specific written authorization, stop concreting operations when a descending air temperature in the shade and away from artificial heat falls below 40°F (4°C), or do not resume until an ascending air temperature in the shade and away from artificial heat reaches frozen foundation course or subgrade.
3. Assume all risk of placing concrete in cold weather. Placing concrete during cold weather does not relieve the Contractor of the responsibility for obtaining the specified results. Remove and replace all concrete injured by frost at Contractor expense.
4. Before any concrete is placed, remove all ice, snow and frost completely from the formwork receiving the concrete.
5. Heating and Placing Concrete
    a. When concreting is authorized during cold weather, assure concrete temperature meets ASTM C94.
6. Protection of Concrete
    a. During the curing period, if the air temperature is anticipated to fall below 32°F (0°C, provide an approved blanket type insulating material along the work for covering all concrete that has been in place for 7 days or less. If, at any time, the ambient temperature drops to 32°F(O°C) or less, protect the concrete using a method approved by the Engineer. The minimum method of protection under such conditions is as follows: between two layers of plastic sheeting, the

insulating materials, with the exception of commercial blankets, must be spread loosely to a minimum depth of 6 inches (150mm), but in all cases, to the depth required to prevent freezing of, or frost damage to, the concrete. Maintain the blanketing material at least until the end of the regular specified curing, period which is not less than 7 days. The Engineer may direct leaving the blanketing material in place for an additional period if the recorded temperatures indicate that additional curing may be necessary. If during the construction period the mean daily temperature is expected to fall below 40°F(4°C) for 3 consecutive days, furnish approved heating enclosures and devices capable of maintaining the surface temperature of the concrete in place between 55°F (13°C) and 80°F (26°C). The curing, period under these conditions is 7 days when Type I-II cement is used and 5 days when a pre-approved "high early strength" mix is used. At the close of the curing period, the heat may be reduced so that the temperature inside the housing does not decrease faster than 15° per hour until the temperature inside the housing is the same as outside.

b. A Contractor may, at their own expense, field cure concrete cylinders with their in-place concrete and discontinue protection when those field cylinders reach 70 percent of design strength as indicated by the 28 day requirement of these specifications.

c. Perform all concrete protection using methods consistent with ACI-306-1-87 and approved by the Engineer.

3.07 TESTING

A. All concrete must be tested by an ACI Grade I or equivalent certified testing technician. Unless otherwise specified, the engineer shall be responsible for all acceptance testing during the on-site placement of the concrete.

1. Materials

a. The Engineer or their representative must have access to the ready mix production facility for sampling constituent materials during production to assure the materials meet these specifications and represent those stated on the approved mix design.

2. Standard Slump Tests

a. The Engineer shall, during each day's placement, check the consistency of the concrete by slump test. A slump test will also be made each time that strength specimens are made. Slump tests are performed meeting ASTM C143"Method of Test for the Slump of Portland Cement Concrete".

3. Compression Tests

a. A minimum of three specimens, 6 inch (150 mm) in diameter or 4 inch(100 mm) , shall be made and tested for every concrete placement. Mold and test one set of test cylinders for every 100 yards (76.5 cubic meters) of concrete or fraction thereof placed each day. On a given project, if the total volume of concrete is such that frequency of testing required above would generate less than 5 strength tests for a given class of concrete, make tests from at least 5 randomly selected batches or from each batch if fewer than 5 batches are used. Cure these

cylinders under laboratory conditions except that additional test cylinders cured entirely under field conditions may be required by the Engineer to check the adequacy of curing and protection of the concrete.

b. Take samples for strength tests in accordance with ASTM C172, entitled "Standard Practice for Sampling Freshly Mixed Concrete."

c. Mold test cylinders and laboratory-cure in accordance with ASTM C31. Test cylinders in accordance with ASTM C39, entitled ""Method of Test for Compressive Strength of Cylindrical Concrete Specimens", ASTM C39, using an independent testing laboratory, as approved by the Engineer.

d. Of each of the 3 cylinders take for a pour, test 1 for information strength at 7 days and test 2 for acceptance strength at 28 days. To meet this specification, average strength of two cylinders from the same sample, tested at 28 days or the specified earlier age, is required for each strength test. Strength level of an individual class of concrete is considered satisfactory if both of the following requirements are met:

    1) The average of all sets of 3 consecutive tests equal or exceed the specified strength.
    2) No individual strength test (average of two cylinders) falls below specified strength by more than 500 psi (3400 kPa).

e. Cure field cured cylinders under field conditions meeting Section 7.4 of "Method of Making and Curing Concrete Test Specimens in the Field" (ASTM C31).

f. Mold field cured test cylinders at the same time and from the same samples as laboratory cured test cylinders. Improve procedures for protecting and curing concrete when strength of field cured cylinders at the test age designated for measuring specified strength is less than 85 percent of that of companion laboratory cured cylinders. When laboratory cured cylinder strengths are appreciably higher than the specified strength, field cured cylinder strengths need not exceed the specified strength by more than 500 psi (3400 kPa) even though the 85 percent criterion is met.

g. The strengths of any specimens cured on the job are to indicate the adequacy of protection and curing of the concrete and may be used to determine when the forms may be stripped, shoring removed or the structure placed in service. When the strengths of the job cured specimens are below those specified above, the Contractor must improve the procedures for protecting and curing the concrete.

h. When concrete fails to meet the requirements above or when tests of field cured cylinders indicate deficiencies in protection and curing, the Owner's representative may order tests on the hardened concrete under Chapter 17.3 of ACI-301-84 or order load tests in Chapter 20 of the ACI Building Code (ACI 318-83) for that portion of the structure where the questionable concrete has been placed. In the event the load or core tests indicate that the structure is unsatisfactory, make all modifications as directed by the Engineer to make the structure sound. If the load or core tests indicate the concrete is satisfactory, all cost of testing shall be paid by Owner.

4. Air Content Tests

    a. a. The Engineer shall during each strength test, check the air content by either the "Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method" (ASTM C23 1), "Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method" (ASTM C173) or "Method of Test for Unit Weight, Yield and Air Content (Gravimetric) of Concrete" (ASTM C138)

5. Temperature

    a. Test hourly when air temperature is 40°F (4°C) and below, and when 80°F (27°C) and above; and each time a set of compression test specimens is made.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

A. The method of measurement and basis of payment is as outlined in the specifications for the various items of concrete work.

4.02 REQUIRED SUBMITTALS

A. A. The following are submittals required to become an approved source of supply for Portland Cement concrete placed in the City right-of-way:

1. Complete concrete mix design meeting all specification requirements. Meet the Mix proportions specified in ACI 301, Chapter 3. Submittals will include the following:

MIX PROPORTIONS	
-cement in lbs (kgs)	Type and source of supply
-coarse aggregate	Size and source of supply
-fine aggregate	Source of supply
-water, gallons(liters)	City or well
-admixtures,oz/yd3(g/M3)	Brand and description*

*description as retarder, accelerator, air entraining, etc.

B. MATERIALS INFORMATION

1. Specific gravity (bulk s.s.d. Basis) of coarse and fine aggregate and 1 percent absorption-coarse aggregate unit weight (dry-rodded)-ASTM C33 quality tests including the following:

    a. Fine aggregate

        1) gradation AASHTO, T27 and T11 deleterious substances soundness (AASHTO T104) organic impurities (AASHTO T21) mortar-making properties (AASHTO T71)

    b. Coarse aggregate

        1) deleterious substances gradation (AASHTO T27 and T11) soundness (AASHTO T104) percentage of wear (AASHTO T96)

c. Current chemical analysis of mixing water (if well)

d. Current cement mill analysis

2. CONCRETE MIX DATA

a. slump

b. % air

c. unit weight

d. 7 and 28 day compressive strength

3. VARIATIONS

a. a. The following variations will be cause for submittal of a new mix design.

1) Change of aggregate source
2) Change of cement content
3) Addition or exclusion of certain admixtures including, but not limited to, pozzolans, accelerators, retarders and water reducers
4) Change in aggregate size
5) Change in type of cement
6) Failure to attain strength requirements as outlined in ACI 214 or ASTM C94

b. A variation in any of the following will require 'Informing the City Engineer and possibly data indicating acceptability for use in existing mix designs.

1) Change of cement supplier
2) Change of admixture brands or dosages (not types)
3) Minor adjustments of aggregate proportions accompanying materials changes or to accommodate placement conditions (same w/c ratio)

C. Certification of Ready Mixed Concrete Production Facilities

1. Concrete producers are to allow access to their facilities by Engineer or their representatives for inspecting their facilities and/or sampling materials. All facilities should meet the requirements of the "National Ready-Mix Concrete Association" check list for concrete production facilities.

2. Items directly affecting a facility's ability to properly proportion, transport and deliver concrete may be reason for disqualifying that facility as a source of supply until such deficiencies are corrected. Examples would include cement and aggregate scales that will not accurately weight materials or mixer units that will not thoroughly mix concrete materials.

D. The following chart indicates the submittal frequency for each item required for approval as a source of supply.

TABLE 4.1
SUBMITTAL FREQUENCY

SUBMITTAL	FREQUENCY		
	Monthly	Twice Yearly	Other
1- Complete mix design			(See Item 1, No 4)
2. Aggregate gradations	X		With mix design
3. L.A. Abrasion			With mix design
4. Soundness			With mix design
5. Deleterious substances			With mix design
6. Water quality (if well)		X	
6a. Cube strengths and time of set			With mix design
7. Cement mill certificates	X		
8. Organic Impurities			With mix design
9. Inspection of facilities			As indicated

Note: The above chart applies to the first year of this program. Frequency of submittals may change as dictated by variations of test data.

END OF SECTION

APPENIDX A
GEOTECHNICAL REPORT

CASTLE ROCK
CIVIL & GEOTECHNICAL ENGINEERING

PROJECT: **Geotechnical Investigation –**
Engineered Pipeline Design for Upper Red Rock Lake, Arctic Grayling Winter Habitat Improvement
SW ¼ of the SW ¼ of the SE ¼ of Section 20
Township 14 South, Range 1 West
Upper Red Rock Lake, Montana-Idaho Quadrangle

CLIENT: Water & Environmental Technologies
480 East Park Street
Butte, Montana
59701

PROJECT NO.: 021071CR

DATE: September 3rd, 2021

INTRODUCTION

A Subsurface Test Hole Investigation was completed on August 18, 2021 by Castle Rock Geotechnical and Water and Environmental Technologies for the proposed pipeline that would bring oxygenated water from Shambow Pond towards the center of Upper Red Rock Lake. The pipeline would expand Lake Habitat by providing improved oxygen concentrations when ice covers the lake.

The purpose of the subsurface investigation is to evaluate subsurface ground conditions and soils which will aid in determining potential construction methods and their impacts. The project consists of an aeration structure, gravity pipeline, and the outlet/discharge port.

Regards,
Andrew Pilskalns P.E.

LOCATION

The project is located in the south ½ of Southeast ¼ of the Southeast ¼ of Section 20, Township 14 South, and Range 1 West. FIGURE 1 – Vicinity, Site and Topographic Map in the Attachments shows a snip of the Upper Red Rock Lake Topographic Map. The project is approximately 31.6 miles east of the Town of Monida, Montana off Interstate 15 in Beaverhead County. The site is at an elevation of 6630 feet above sea level. The proposed water pipe alignment is on gently sloping grounds. Gently sloped grounds as defined by the NRCS are from 1 percent, lower limit to 8 percent, upper limit slopes.

SUBSURFACE INVESTIGATION AND SOIL TEST RESULTS

The sub-surface investigation was completed on August 18th, 2021 utilizing hand held shovels, post-hole digger and tamping bar. The terms “bore” and “test hole” are interchangeable in this report.

Test Hole locations were predetermined by WET and are shown in FIGURE 2 – Test Hole and Pipe Alignment Map. The two test hole Bore Logs are found in the Attachments at the end of this report along with Photo Logs. The subsurface grounds consist of:

Test Hole 1 – Soil Profile	
Depth (In)	USDA Texture
0-12	Organic Loam
12-24	Clay Loam W Sand
24-48	Silty sandy loam with gravels
48-60	Silty clay loam
60-72	Silty sandy loam w/gravels

Test Hole 2 – Soil Profile	
Depth (In)	USDA Texture
0 - 6	Organic Loam
6 -72	Fat clay

Test Holes 1 and 2 consist of Fens on alluvial fan deposits. The Fens are peat-forming wetland being recharged by groundwater. Fens are a type of wetland, taking thousands of years to form.

The Soil Test Results for the three samples from the test holes are found in the Attachments at the end of this report. Castle Rock Geotechnical tested soils believed to be at the pipe burial depth which may vary from 4 to 6 feet below grade. Atterberg, Gradation, Hydrometer and Organic Content Reports were completed. Photos of Test Holes 1 and 2 are found in the Attachments.

Research indicates that the soils along the alignment are MODERATELY corrosive to concrete. The rate of corrosion to concrete is electrochemical or chemical action that weakens unprotected concrete. Sulfate resistant concrete should be used or concrete should be coated to protect it from the soils. The risk of corrosion to steel is HIGH. Steel piping should have cathodic protection or coating. Steel piping is not recommended.

GEOTECHNICAL INFORMATION

Utilizing, United States Geologic Survey (USGS) Surficial Geologic Map of the Red Rock Lakes Area, Southwest Montana the primary mapping unit symbol that the pipe line alignment passes through is Qpia - Lake Centennial deposits and alluvium (late Pleistocene). The lake and ground along its borders are Qlc, Lacustrine Deposits. The Pleistocene Epoch is 2.6 million years ago and lasted about 11,700 years. The lake is within a hanging glacial valley formed by glaciation and complex faulted grounds. The Centennial Normal fault is approximately 1 mile from the project. The Geologic Map gives a good idea of how groundwater recharge affects the area and Upper Red Rock Lake. The field samples logged and tested verify that the grounds consist on the upper plain near Shambow Pond consist of alluvial deposit and soils near the lake are lacustrine deposits, clay.

GROUNDWATER

No groundwater was observed in either test hole down to 6 feet below grade. The clay soils were very moist and plastic. In our opinion groundwater is likely controlled by regional precipitation, and during periods of reoccurring large precipitation events, groundwater may raise 2 to 3 feet. Many springs are located in the near vicinity of Shambow Lake. The pipeline alignment appears to be the high ground down to the target pipeline discharge area.

SEISMIC CONSIDERATION

Based on the results of our sub-surface investigation and review of available geologic information, we anticipate the upper 100 foot profile will be comprised of sedimentary and lacustrine deposits of soft and stiff silt, sand, fat clay. In addition, groundwater influence is significant. The risk of liquefaction at this site is high in the event of violent ground motion. Liquefaction is when a significant ground shaking event can cause loose unconsolidated material, saturated with water to subside, or deform. This can cause lateral spread and cracks opening in the ground. During an event water and sand may erupt through the cracks creating sand blows, cones of sand. No liquefaction has been reported along the southern part of the valley, in the general area of Upper Red Rock Lake. A dozen or so are located on the northern side of the valley.

RECOMMENDATIONS

The lowest impact in constructing a water pipeline down to Upper Red Rocks Lake would be directional drilling. The upper peat is very resilient and thick, allowing for equipment to operate upon it without great impact. A horizontal directional drill/bore would have to be sized so that it can perform the work but not overly enlarge the site. An all-terrain drill utilizing HDPE pipe should be considered. The water pipe alignment is 6,298 feet long from Shambow Pond to the desired location of discharge. Steel piping is not recommended for this project due to the risk of corrosion. The aerator vault should consist of a durable plastic insulated tank with heavy insulated cover. Water tight AP Foil-Faced Polyisocyanurate Continuous Insulation can cover the tank with an oversize zone of 4 feet on all sides. The insulation is to be 2 inch panel's seam taped together utilizing the manufactures proprietary tape. The foil sides should be facing down and up. This is the most water resistant insulation board on the market. Care must prevent the puncture of the insulation so the base of the panels can be bedded in pea gravel.

The recommendations made are based on the initial geotechnical input and the Geotechnical Engineer should remain involved during construction.

Castle Rock Geotechnical is a member of the Geoprofessional Business Association (GBA). To better understand how geotechnical reports are to be interpreted please read Important Information about Your Geotechnical Report provided by GBA, found in the Attachments. This report is for the use of the Client and the project referenced above. Revision or use of this report for any other project is prohibited.

I hereby certify this report was prepared by me and that I am a duly licensed Professional Engineer under the laws of the State of Montana.

I appreciate the opportunity to work with you.

Prepared By:
Andrew Pilskalns, P.E., M.ASCE, M.GBA
Civil Engineer

LICENSED – Montana, Utah, Colorado, Hawaii, Nevada, Wyoming

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[1] - Montana Bureau of Mines and Geology; [2] - Montana Technological University

Soil Survey Staff Natural Resources Conservation Service, Untitled Sates Department of Agriculture Available online at the following link: http://websoilsurvey.sc.egov.usda.gov/.
September 3rd, 2021

ATTACHMENTS

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT Pg. 20, 21

GEOTECHNICAL TERMINOLOGY

CASTLE ROCK
CIVIL & GEOTECHNICAL ENGINEERING

Standard D 2487
Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[E]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[C]	GW	Well-graded gravels[D]
			$Cu < 4$ and/or $1 > Cc > 3$[C]	GP	Poorly-graded gravels[D]
		Gravels with Fines More than 12% fines[E]	Fines classify as ML or MH	GM	Silty gravel[D, F, G]
			Fines classify as CL or CH	GC	Clayey gravel[D, F, G]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[I]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[C]	SW	Well-graded sand[H]
			$Cu < 6$ and/or $1 > Cc > 3$[C]	SP	Poorly-graded sand[H]
		Sand with Fines More than 12% fines[I]	Fines classify as ML or MH	SM	Silty sand[F, G, H]
			Fines classify as CL or CH	SC	Clayey sand[F, G, H]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K, L, M]
			PI < 4 or plots blow "A" line[J]	ML	Silt[K, L, M]
		organic	$\frac{\text{LL (oven dried)}}{\text{LL (not dried)}} < 0.75$	OL	Organic clay[K, L, M, N] Organic silt[K, L, M, O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K, L, M]
			PI plots below "A" line	MH	Elastic silt[K, L, M]
		organic	$\frac{\text{LL (oven dried)}}{\text{LL (not dried)}} < 0.75$	OH	Organic clay[K, L, M, P] Organic silt[K, L, M, Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] $Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2 / D_{10} \times D_{60}$
[D] If soil contains ≥15 % sand, add "with sand" to group name.
[E] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[G] If fines are organic, add "with organic fines" to group name.
[H] If soil contains ≥15 % gravel, add "with gravel" to group name.
[I] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥30 % plus No. 200, predominantly sand, add "sand" to group name.
[M] If soil contains ≥30 % plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

Particle Size Identification

Boulders	over 12"
Cobbles	3" to 12"
Gravels	
coarse	3/4" to 3"
fine	No. 4 to 3/4"
Sand	
coarse	No. 4 to No. 10
medium	No. 10 to No. 40
fine	No. 40 to No. 200
Silt	No. 200 to 0.005 mm
Clay	less than 0.005 mm

Relative Density of Cohensionless Soils BPF = Blows Per Foot

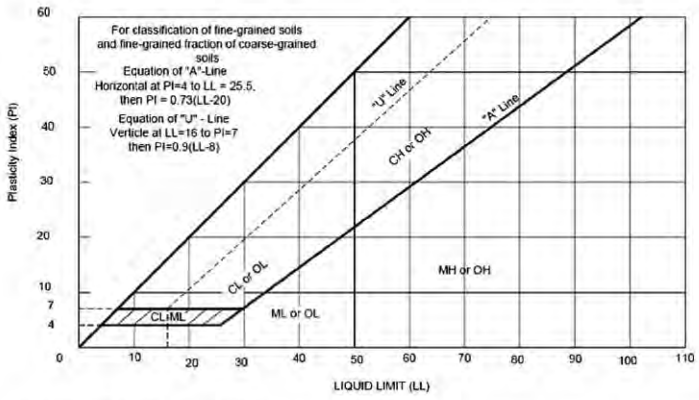
very loose	0 to 4 BPF
loose	5 to 10 BPF
medium dense	11 to 30 BPF
dense	31 to 50 BPF
very dense	over 50 BPF

Consistency of Cohesive Soils

very soft	0 to 1 BPF
soft	2 to 3 BPF
rather soft	4 to 5 BPF
medium	6 to 8 BPF
rather stiff	9 to 12 BPF
stiff	13 to 16 BPF
very stiff	17 to 30 BPF
hard	over 30 BPF

Moisture Content (MC) Description

rather dry	MC less than 5%, absence of moisture, dusty
moist	MC below optimum, but no visible water
wet	MC over optimum, visible free water, typically below water table
saturated	Clay soils where MC over optimum



Laboratory Tests Terminology

DD	Dry density, pcf	OC	Organic, content %
WD	Wet density, pcf	P200	Percent passing 200 sieve
qu	Unconfined compressive strength, psf		
qp	Pocket penetrometer strength, tsf		
LL	Liquid Limit		
PL	Plastic Limit		
PI	Plasticity Index		
MC	Natural moisture content, %		

USDA Textural Soil Classification

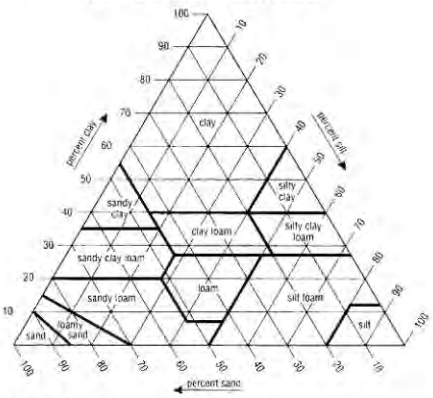


PLATE No. 1

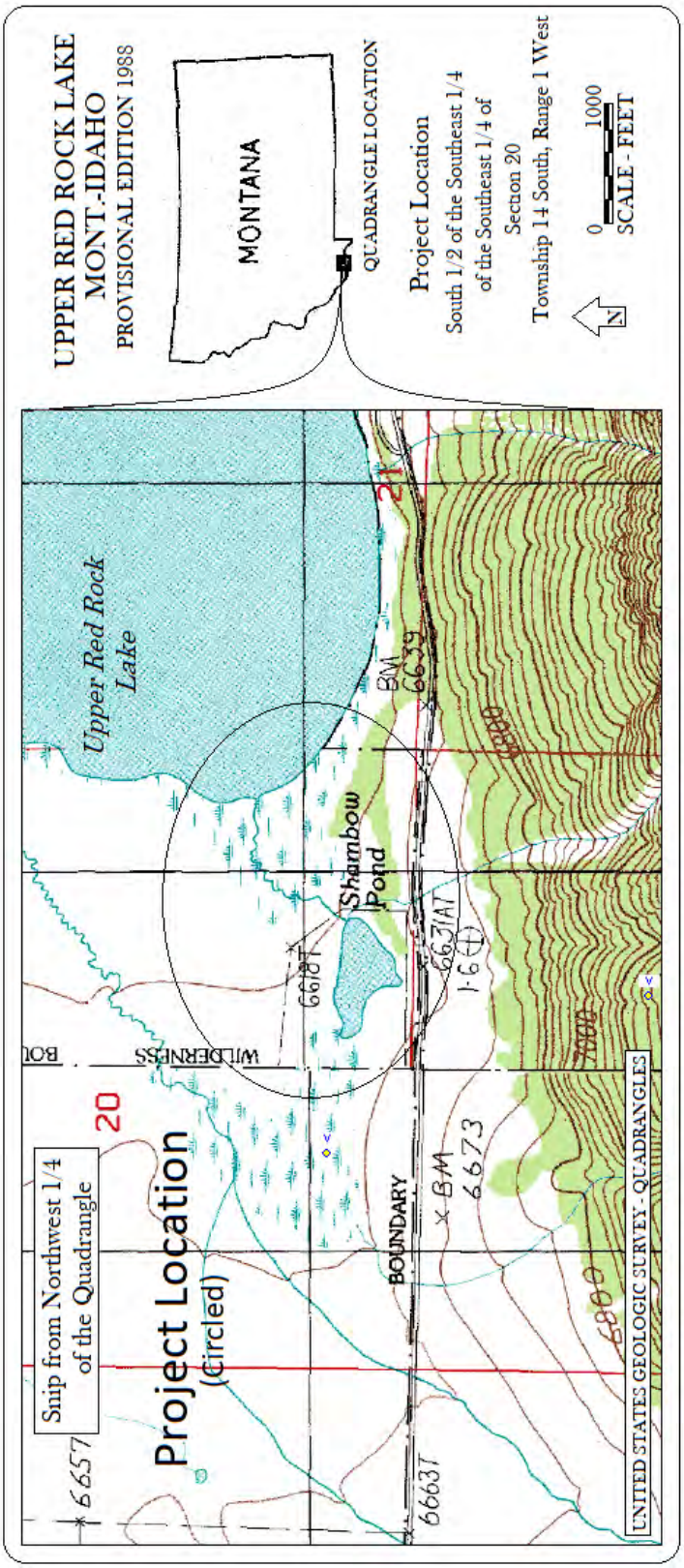


FIGURE 1 - VICINITY - PROJECT - TOPOGRAPHIC MAP

PREPARED FOR: MONTANA FISH, WILDLIFE & PARKS

PREPARED BY: CASTLE ROCK GEOTECHNICAL ENGINEERING

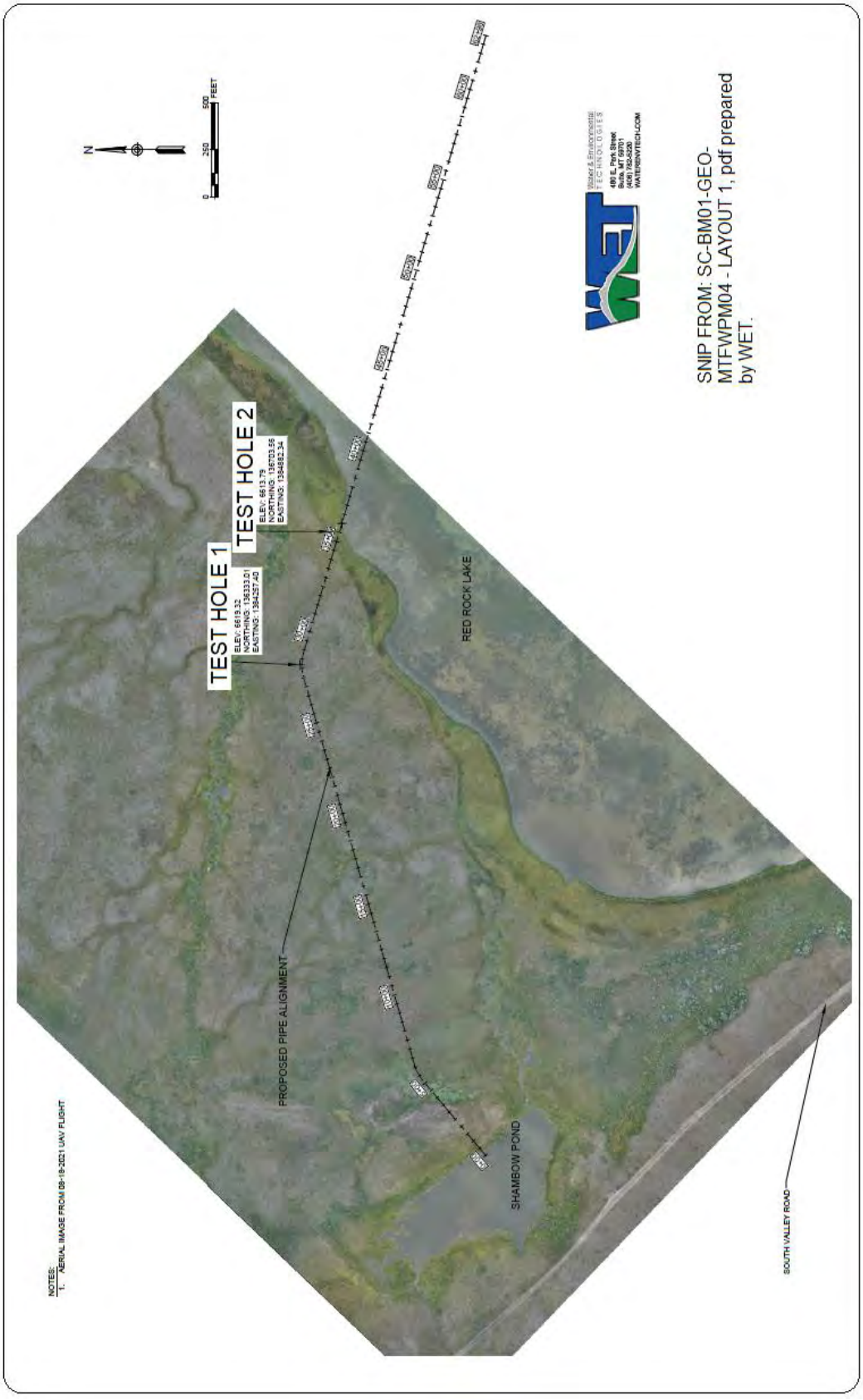


FIGURE 2 - TEST HOLE MAP - PIPE ALIGNMENT

PREPARED FOR: MONTANA, FISH WILDLIFE AND PARKS

PREPARED BY: CASTLE ROCK GEOTECHNICAL

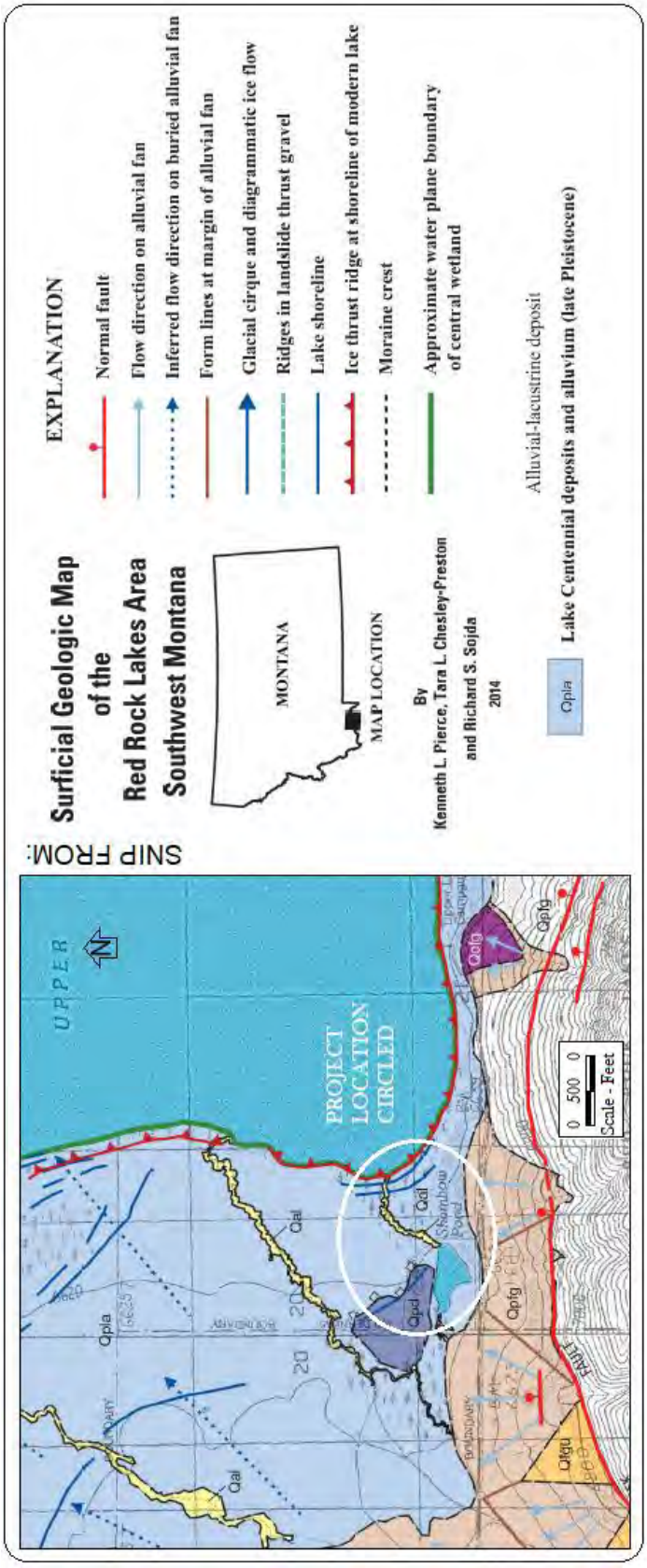


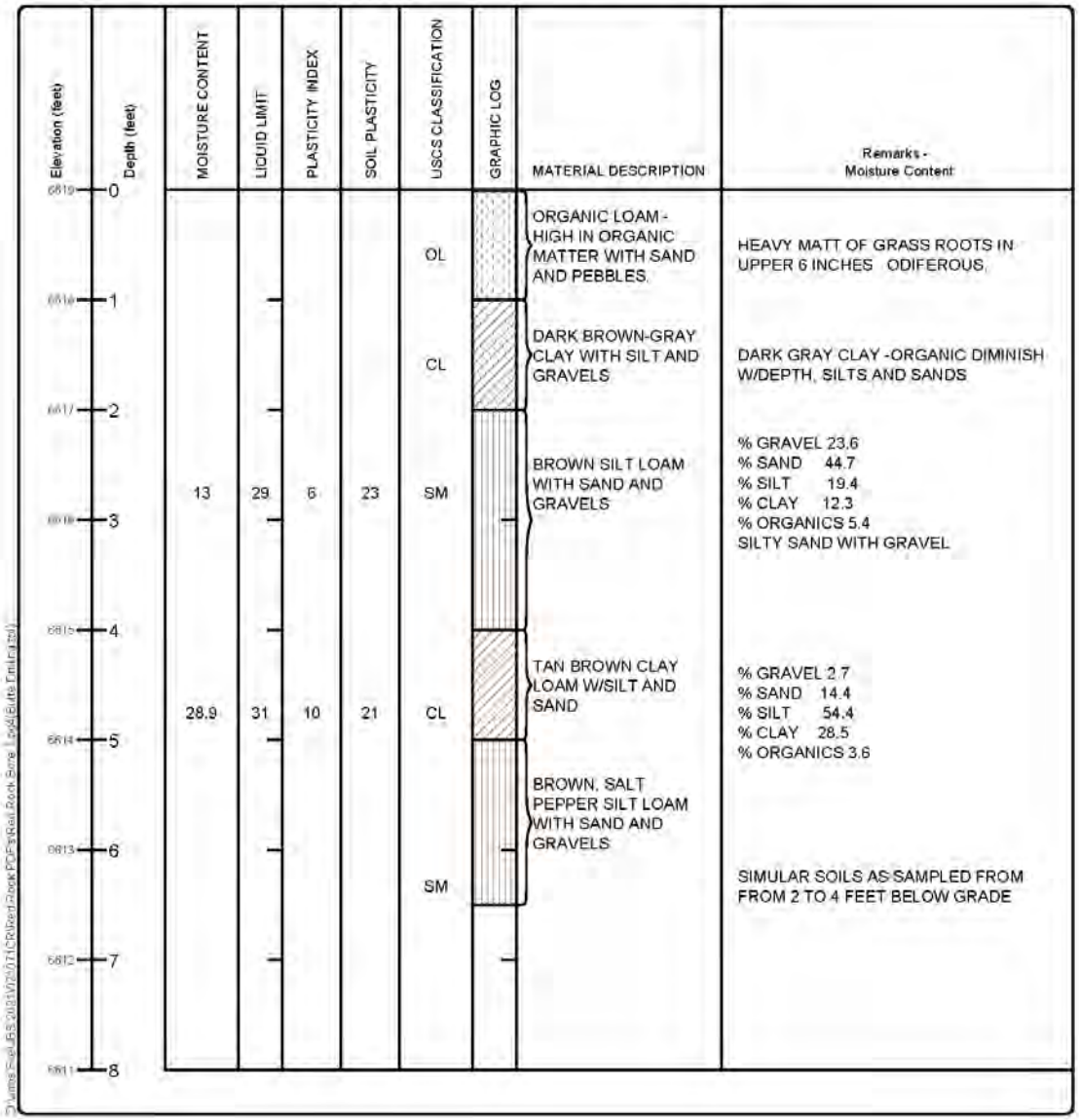
FIGURE 3 - GEOLOGIC MAP

ARCTIC GRAYLING HABITAT IMPROVEMENT WATER PIPELINE

PREPARED FOR FISH WILDLIF AND PARKS

Project: **Artic Grayling Habitat Improvement Study** Project Location: **Upper Red Rocks Lake** Project Number: **021071CR**	Log of Boring Bore 1 **Sheet 1 of 1**

FIELD WORK DATES: **August 18th, 2021**	ASSISTED BY: **CALEB LOCKYER**	
FIELD TOOLS: **SHOVELS, POST HOLE DIGGER**		TOTAL DEPTH: **6'-6"**
LOGGED BY: **ANDREW PILSKALNS P.E.**		GROUND ELEVATION: **6619**
GROUNDWATER: **NO GROUNDWATER OBSERVED**	Sampling Method(s): **GRAB BAG**	WEATHER: **OVERCAST, RAIN, COOL**
BACKFILL USED: **NATIVE SOILS FROM TEST HOLE**	Location: **STATION 28 + 20 OF THE PIPELINE ALIGNMENT**	



Project: **Artic Grayling Habitat Improvement Study** Project Location: **Upper Red Rocks Lake** Project Number: **021071CR**	Log of Boring Bore 2 **Sheet 1 of 1**

FIELD WORK DATES **August 18th, 2021**	ASSISTED BY **CALEB LOCKYER**	
FIELD TOOLS **SHOVELS, POST HOLE DIGGER**		TOTAL DEPTH **6'-6"**
LOGGED BY **ANDREW PILSKALNS P.E.**		GROUND ELEVATION **6613.79**
GROUNDWATER **NO GROUNDWATER OBSERVED**	Sampling Method(s) **GRAB BAG**	WEATHER **OVERCAST, RAIN, COOL**
BACKFILL USED **NATIVE SOILS FROM TEST HOLE**	Location **STATION 35+25 OF THE PIPELINE ALIGNMENT**	

Elevation (feet)	Depth (feet)	MOISTURE CONTENT	LIQUID LIMIT	PLASTICITY INDEX	SOIL PLASTICITY	USCS CLASSIFICATION	GRAPHIC LOG	MATERIAL DESCRIPTION	Remarks - Moisture Content
6613.79	0					OL-OH		ORGANIC LOAM - WITH CLAY, SILT SAND.	HEAVY MATT OF GRASS ROOTS IN UPPER 6 INCHES. ODIFEROUS.
6612.79	1							GRAY CLAY	
6611.79	2								
6610.79	3								PORTABLE STATIC CONE PENETROMETER USED TO MEASURE CONSISTANCY OF CLAY TEST UNIFORM WITH DEPTH .5 TONX/SQFT SOFT TO MEDIUM CONSISTANCY
6609.79	4								
6608.79	5								
6607.79	6	30.7	60	36	24	CH			% GRAVEL 0.0 % SAND 5.7 % SILT 25.3 % CLAY 69 % ORGANICS 2.6
6606.79	7								
6605.79	8								

C:\Jobs File\JBS 2021\021071CR\BORE LOG 2.bgd\Bills Drilling.tpl

Project: **Artic Grayling Habitat Improvement Study** Project Location: **Upper Red Rocks Lake** Project Number: **021071CR**	Key to Log of Boring **Sheet 1 of 1**

Elevation (feet)	Depth (feet)	MOISTURE CONTENT	LIQUID LIMIT	PLASTICITY INDEX	SOIL PLASTICITY	USCS CLASSIFICATION	GRAPHIC LOG	MATERIAL DESCRIPTION	Remarks - Moisture Content
1	2	3	4	5	6	7	8	9	10

COLUMN DESCRIPTIONS

1 Elevation (feet): Elevation (MSL, feet).
2 Depth (feet): Depth in feet below the ground surface.
3 MOISTURE CONTENT: SOIL NATURAL MOISTURE CONTENT IN %
4 LIQUID LIMIT: ATTERBERG LIMIT TEST
5 PLASTICITY INDEX: Plasticity Index, expressed as a % water content.
6 SOIL PLASTICITY: Plasticity of Soil: HP, Highly Plastic, Moderately Plastic, MP or Low Plasticity, LP, or Non-plastic, NP. It may also be expressed as a % of Soil Moisture.
7 USCS CLASSIFICATION: USCS Symbol
8 GRAPHIC LOG: Graphic depiction of the subsurface material encountered.
9 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
10 Remarks - Moisture Content: Comments and observations regarding drilling or sampling made by Engineer, Driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PL: Plastic Limit, (percent)
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

Lean CLAY, CLAY w/SAND, SANDY CLAY (CL)
Low plasticity PEAT (OL)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
Bulk Sample
3-inch-OD California w/ brass rings
CME Sampler
Gravels with Silt fines
Grab Sample
3 inch minus pit run gravels with silt fines
2.5-inch-OD Modified California w/ brass liners
Pitcher Sample
2-inch-OD unlined split spoon (SPT)
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

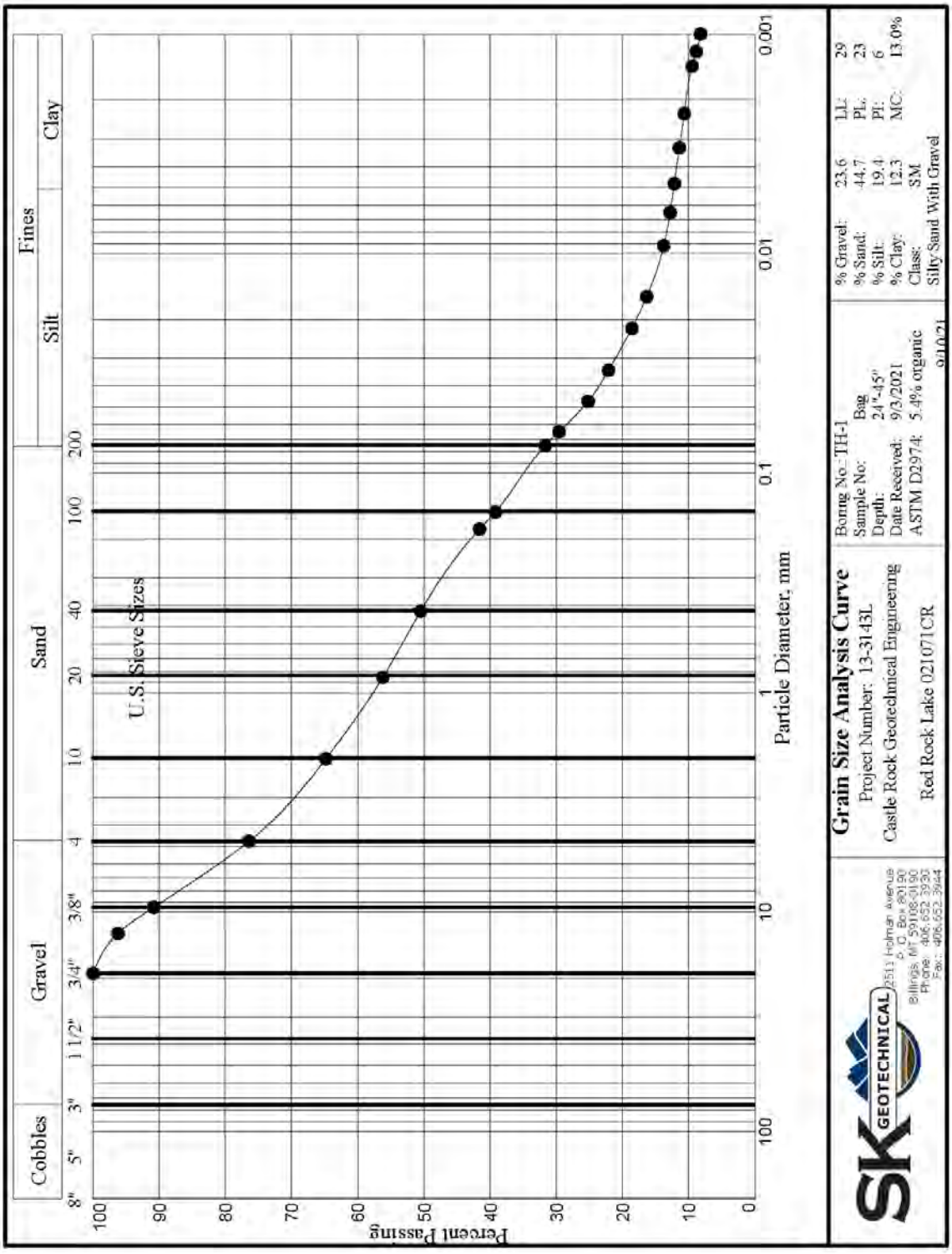
Figure B-1

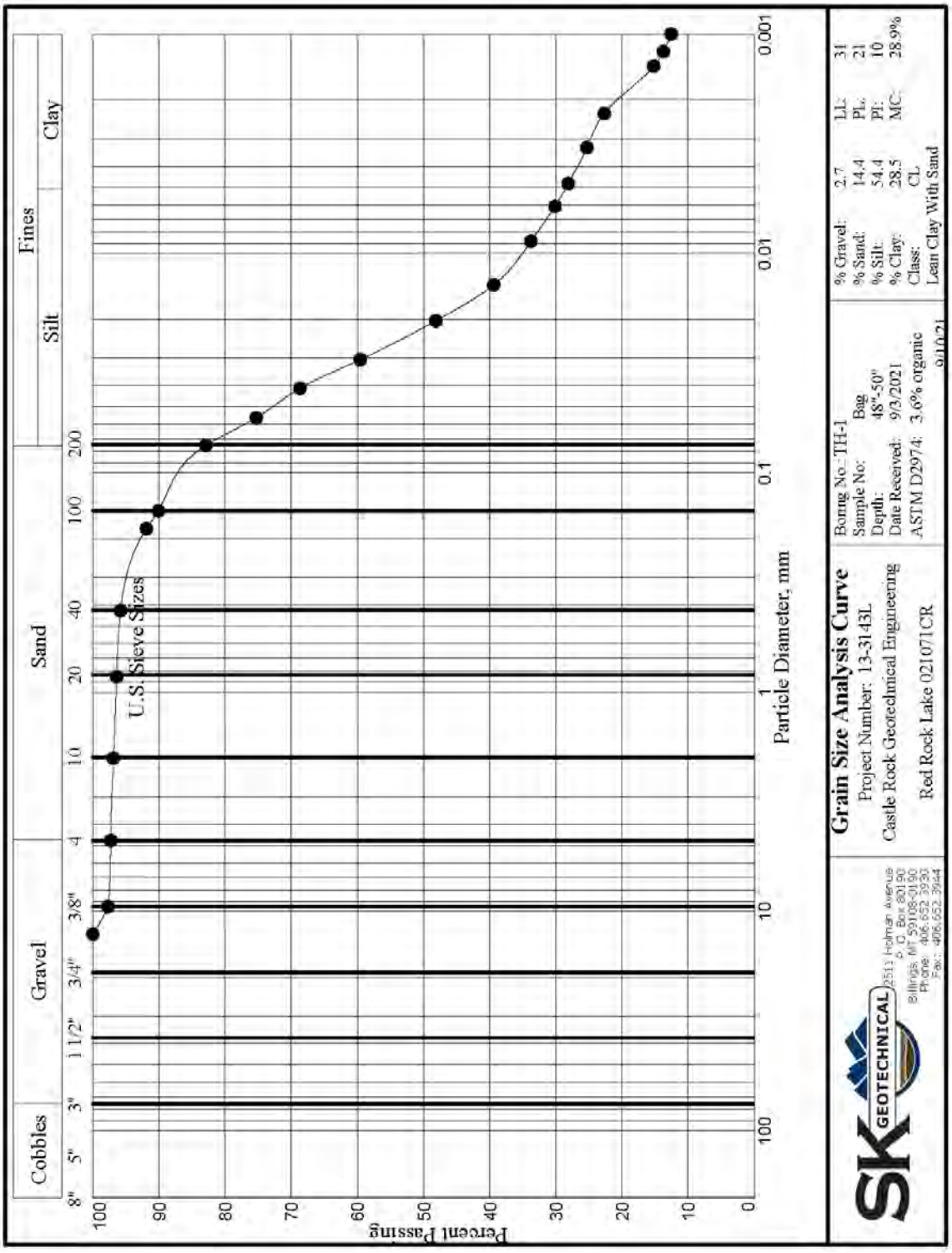
Photo 1 - TEST HOLE 1

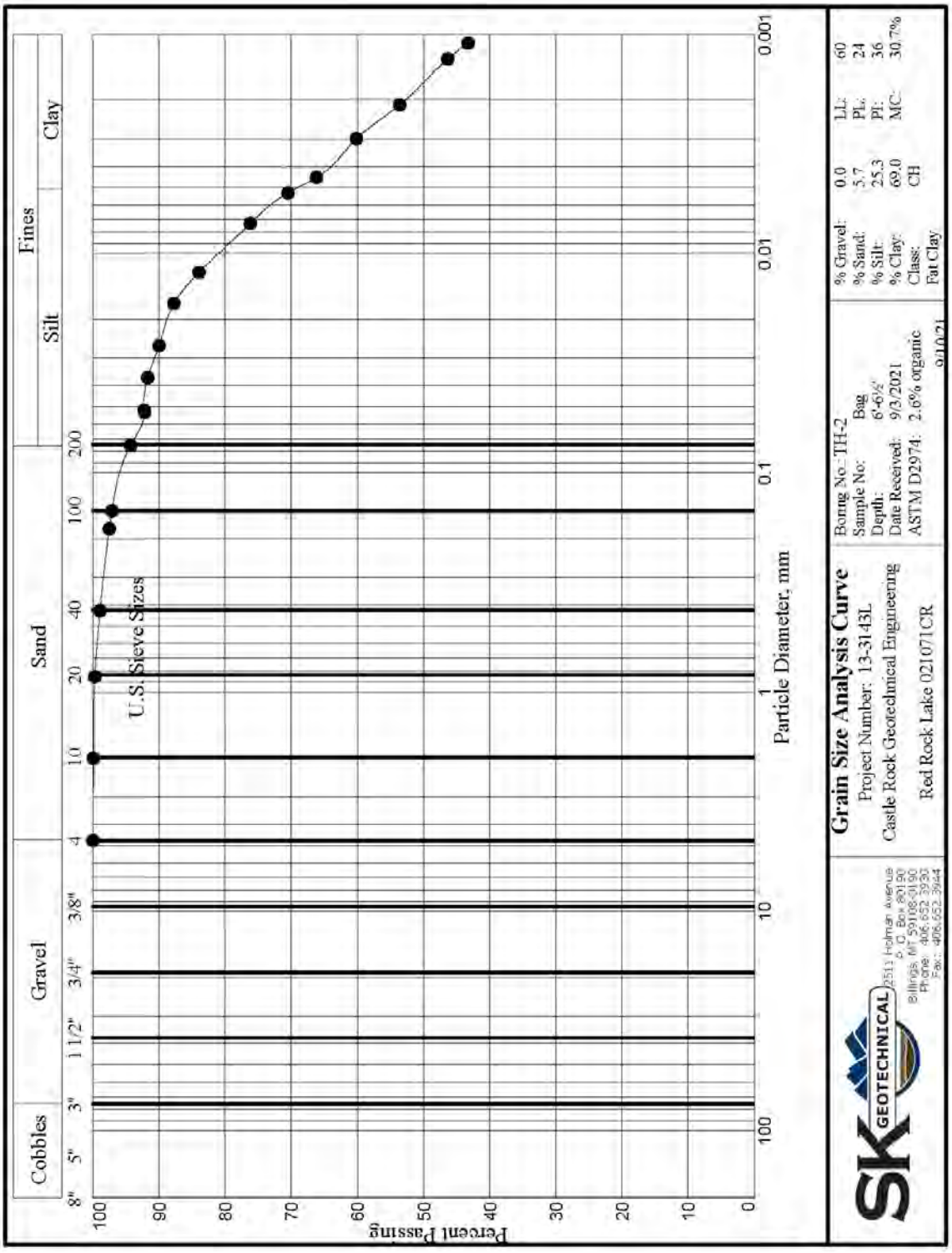
UPPER RED ROCKS LAKE AUGUST 18, 2021

Photo 2 - TEST HOLE 2

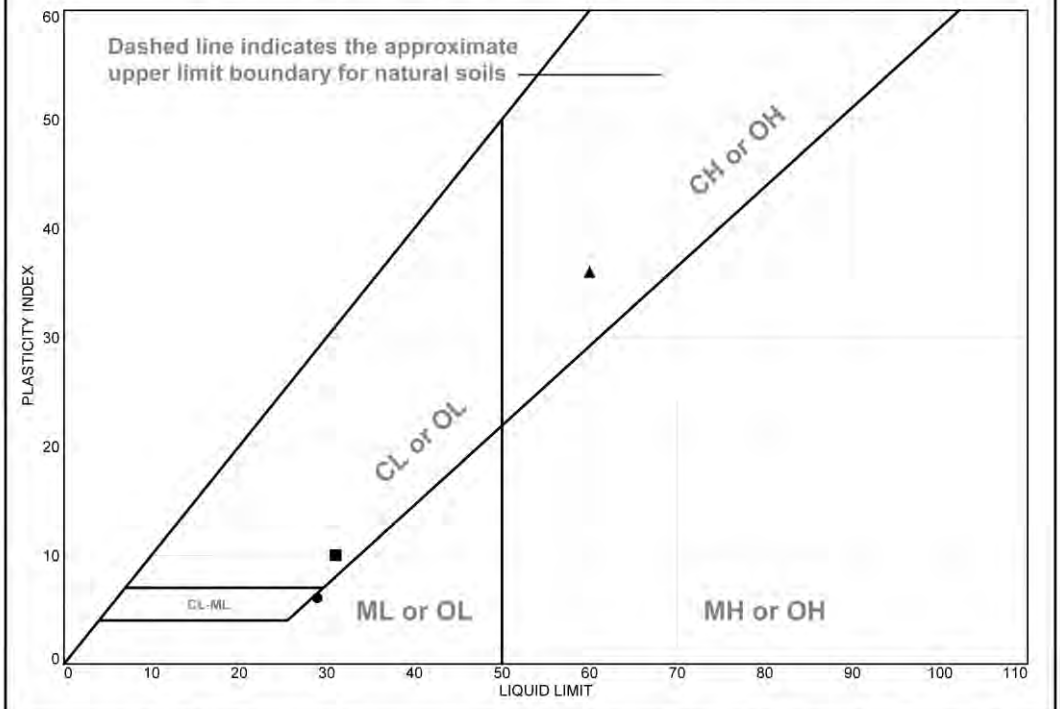
UPPER RED ROCKS LAKE AUGUST 18, 2021


Cobbles
Gravel
Sand
Fines
Silt
Clay
8"
5"
3"
1 1/2"
3/4"
3/8"
4
10
20
40
100
200
U.S. Sieve Sizes
Percent Passing
Particle Diameter, mm
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
Grain Size Analysis Curve
Project Number: 13-3143L
Castle Rock Geotechnical Engineering
Red Rock Lake 021071CR
Boring No.: TH-1
Sample No: Bag
Depth: 24"-45"
Date Received: 9/3/2021
ASTM D2974: 5.4% organic
% Gravel: 23.6
% Sand: 44.7
% Silt: 19.4
% Clay: 12.3
Class: SM
Silty Sand With Gravel
LL: 29
PL: 23
PI: 6
MC: 13.0%
9/10/21
SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944


Cobbles
Gravel
Sand
Fines
Silt
Clay
8"
5"
3"
1 1/2"
3/4"
3/8"
4
10
20
40
100
200
U.S. Sieve Sizes
Percent Passing
Particle Diameter, mm
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
Grain Size Analysis Curve
Project Number: 13-3143L
Castle Rock Geotechnical Engineering
Red Rock Lake 021071CR
Boring No.: TH-1
Sample No: Bag
Depth: 48"-50"
Date Received: 9/3/2021
ASTM D2974: 3.6% organic
% Gravel: 2.7
% Sand: 14.4
% Silt: 54.4
% Clay: 28.5
Class: CL
Lean Clay With Sand
LL: 31
PL: 21
PI: 10
MC: 28.9%
SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944


Cobbles
Gravel
Sand
Fines
Silt
Clay
8" 5" 3" 1 1/2" 3/4" 3/8" 4 10 20 40 100 200
U.S. Sieve Sizes
Percent Passing
Particle Diameter, mm
Grain Size Analysis Curve
Project Number: 13-3143L
Castle Rock Geotechnical Engineering
Red Rock Lake 021071CR
Boring No.: TH-2
Sample No: Bag
Depth: 6'-6½'
Date Received: 9/3/2021
ASTM D2974: 2.6% organic
% Gravel: 0.0
% Sand: 5.7
% Silt: 25.3
% Clay: 69.0
Class: CH
Fat Clay
LL: 60
PL: 24
PI: 36
MC: 30.7%
9/10/21
SK GEOTECHNICAL
2511 Holman Avenue
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	TH-1 @ 24"-48"	29	23	6	NT	NT	ML
■	TH-1 @ 48"-50"	31	21	10	NT	NT	CL
▲	TH-2 @ 6'0"-6'6"	60	24	36	NT	NT	CH

Project No. 10005.40 **Client:** Castle Rock Geotechnical
Project: Red Rock Lake

●**Location:** Red Rock Lake **Depth:** 24"-48" **Sample Number:** 2161
■**Location:** Red Rock Lake **Depth:** 48"-50" **Sample Number:** 2162
▲**Location:** Red Rock Lake **Depth:** 6'0"-6'6" **Sample Number:** 2163

Remarks:
●ASTM D4318 Moisture=12.5%
■ASTM D4318 Moisture=25.7%
▲ASTM D4318 Moisture=31.3%

CASE

Lab Number 2161-2163

Tested By: G. Murtorff C. Pantori C. Pantori **Checked By:** T. Miller

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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APPENIDX B

CHAPTER 10 – MARINE INSTALLATIONS

Chapter 10

Marine Installations

Introduction

Since the early 1960's, just a few years after its first introduction, polyethylene (PE) piping has been increasingly used for various marine applications such as effluent outfalls, river and lake crossings, and fresh and salt-water intakes. Immunity to galvanic corrosion is a major reason for selecting PE. The combination of air and water, but particularly seawater, can be very corrosive to ordinary metallic piping materials. But other beneficial features, as follows, combine to make PE piping particularly well-suited for marine applications:

Light weight – For a given pipe diameter and equivalent performance requirements, the weight of PE pipe is around one tenth of the weight of concrete pipe and less than one half that of cast iron. Handling of PE requires a minimum of heavy equipment.

It floats – Because PE's density is about 96% of that for fresh water, and about 94% of that for sea water, PE pipe floats even when full of water. Long lengths can be assembled on shore where the empty pipe may be weighted to an extent that allows air-filled pipe to be floated to its intended location, and in most cases, is also sufficiently weighted to keep it anchored at its final submerged location after the air has been replaced with water.

Integral, "bottle-tight" joints – By means of the butt fusion method, continuous lengths of PE pipe can be readily assembled without the need of mechanical fittings. The resultant heat fusion joints are as strong as the pipe, and they eliminate the risk of joint leakage.

Flexibility –The flexibility of PE pipe allows it to be gradually sunk and to adapt to the natural topography of underwater surfaces. This results in a more simplified sinking procedure, and it also means that the flexible pipeline can normally be placed directly on the natural bottom without any trenching or other form of preparation of continuous level support.

Ductility (strainability) – Because of its relatively high strain capacity, PE piping can safely adjust to variable external forces generated by wave and current action. High strain capacity also allows the PE piping to safely shift or bend to accommodate itself to altered bedding that can result by the underscouring that may sometimes occur with strong wave and current actions.

Conventional, non-flexible materials such as concrete or iron pipe can only afford relatively small deformations before risking leakage at, or structural failure of, the joints. As the exact magnitude of the maximum forces that can act on rigid pipes is difficult to predict, installations using piping that only allows relatively small deformation at the joints, or limited bending strain in the pipe, requires a large "safety factor," such as a relatively heavy loading to stabilize the pipe against movement, or the trenching of the pipe into sea bed sediments so as to stabilize it against movement that can result from heavy sea action. Such construction techniques tend to be more difficult, time-consuming and relatively expensive. In contrast, the flexibility and ductility of PE allows it to adapt to unconsolidated river and sea bottoms, and also to safely shift or bend under the forces resulting from occasionally strong currents or other actions. For most marine installations, PE piping needs only to be sufficiently weighted to keep it at the intended location and to prevent it from floating. This results in easier and less costly installations and in a submerged piping system that is capable of delivering very reliable and durable service. By choosing PE pipes, many projects have been accomplished which would not have been economically realistic with traditional piping materials. The lower overall cost of PE piping installations allows for the option of installing several small outfalls rather than one large one. Multiple outfalls can achieve greater environmental protection by the discharging of smaller quantities of effluent at separated points of discharge, and their use often results in lower onshore pretreatment costs.

A marine pipeline installation may involve considerable risk to the pipeline integrity both during installation and while in service. Guidance provided herein on the design and installation of PE piping is limited to those issues that are specific or are related to this

material. It is not the intent of this chapter to cover the many other design, construction and safety issues that need to be considered in a marine installation.

The primary focus of this chapter is the design and installation of underwater lines by the "float-and-sink" method that is made possible through the use of the light-in-weight and flexible PE pipe. Under certain conditions – such as when it is not possible to delay navigation long enough to launch and sink a pipeline – it may be necessary, or it may be more practical, to use a variation of the "float-and-sink" method that is herein described. In one variation, one or more separate long-segments of the pipeline with a flange at each end are assembled and floated. These segments are then sunk, properly positioned and bolted together by divers. Another alternative method is the "bottom-pull" method, which is briefly described at the end of Step 8. However, regardless of which method is used, the general design and installation principles that apply to the "float-and-sink" method also apply to alternate methods.

Other marine applications for which PE piping has proven to be very suitable include temporary water surface pipelines, lines installed over marshy soils and lines used in dredging operations. These are described briefly. Design and installation for these marine applications are conducted in accordance with essentially the same criteria and principles as described for the "float-and-sink" method.

The Float-and-Sink Method – Basic Design and Installation Steps

In nearly all underwater applications, the design and installation of PE piping is comprised of the following basic steps:

1. Selection of an appropriate pipe diameter
2. Selection of an appropriate pipe SDR (i.e., an appropriate wall thickness) in consideration of the anticipated installation and operating conditions
3. Selection of the design, weight and frequency of spacing of the ballast weights that will be used to sink and then hold the pipe in its intended location
4. Selection of an appropriate site for staging, joining and launching the pipe

5. Preparing the land-to-water transition zone and, when required, the underwater bedding
6. Assembly of the individual lengths of pipe into a continuous string of pipe
7. Mounting of the ballast weights (This step may be done in conjunction with the next step.)
8. Launching the joined pipe into the water
9. Submersion of the pipeline into the specified location
10. Completion of the land-to-water transition

General guidance for the conduct of each of these steps follows. Since the specific conduct of each step can be affected by the choice of design and installation options discussed in other steps, the reader should review the entire chapter before deciding on the most applicable design and installation program.

Step 1 Selection of an Appropriate Pipe Diameter

Selection of an appropriate pipe diameter involves the estimation of the minimum flow diameter that is needed to achieve the design discharge rate. Guidance for doing this is provided in Chapter 6 of this Handbook.

A confirmation is then performed after the required pipe dimension ratio (DR) is determined in accordance with Step 2 which follows. Since the actual internal diameter of a pipe that is made to a standard outside diameter is dependent on the choice of pipe DR (see Table in the Appendix A.1 and A.2 in Chapter 6), the nominal pipe diameter/DR combination that is finally selected needs to have an actual inside diameter that is at least as large as the above determined minimum required flow diameter.

Step 2 Determination of the Required DR or SDR

The DR of the PE pipe, in combination with the pipe material's assigned maximum hydrostatic design stress, should allow the pipe to operate safely at the maximum anticipated sustained net internal pressure at the maximum anticipated operating temperature. Information, including temperature and environmental de-rating factors, for determining the appropriate pipe DR is presented in Chapter 6 and in Appendix, Chapter 3 of this Handbook. As an added "safety factor" it is common practice to pressure rate the pipe for the maximum anticipated operating temperature of either the internal or external environment, whichever is higher.

A check should be made to ensure that the selected pipe pressure rating is also sufficient to safely withstand any momentary pressure surges above normal operating pressure. Pressure surges tend to occur during pump start-ups or

shut-downs, and also during sudden pump stops caused by emergencies, such as loss of power. Guidance for selecting a PE pipe with sufficient surge pressure strength is also presented in Chapter 6 of this Handbook.

A sudden pump stop can sometimes also result in flow separation, giving rise to a momentary reduction in pressure along some portion of the pipeline. Since underwater pipelines can be subject to relatively large external hydrostatic pressure, flow separation can sometimes lead to a significant net negative internal pressure. A check needs to be made to ensure that the pipe DR that has been selected based on maximum internal pressure considerations is also adequate to safely resist buckling, or pipe collapse, under the largest net negative internal pressure that could ever develop from whatever cause. Guidance for this design check is also provided in Chapter 6 of this Handbook. The ballast weights that are attached to PE pipe for purposes of its submersion also fulfill an important role as ring stiffeners that tend to enhance a pipe's inherent resistance to buckling. Common design practice is to accept this benefit as an added "safety factor," but not to directly consider it in the design procedure for selection of a pipe of appropriate ring stiffness.

Step 3 Determination of the Required Weighting, and of the Design and the Spacing of Ballast Weights

The determination of these parameters is made in accordance with the following sub-steps.

Step 3a Maximum Weighting that Allows Weighted Pipe to be Floated into Place

The buoyant or vertical lift force exerted by a submerged PE pipe is equal to the sum of the weight of the pipe and its contents minus the weight of the water that the pipe displaces. This relationship can be expressed mathematically as follows:

(1) $$F_B = [W_P + W_C] - W_{DW}$$

WHERE

F_B **= buoyant force, lbs/foot of pipe**

W_P **= weight of pipe, lbs/foot of pipe**

W_C **= weight of pipe contents, lbs/foot of pipe**

W_{DW} **= weight of water displaced by pipe, lbs/foot of pipe**

Since the density of PE (~59.6 lbs/cubic foot) is only slightly lower than that of fresh water (~62.3 lbs/cubic foot) the pipe contributes somewhat towards net buoyancy. However, the major lift force comes from the air-filled inner volume of the pipe. Since, for a pipe of given outside diameter, the size of the inner volume is determined by the pipe's wall thickness – the greater the thickness, the smaller the

inner volume – and since a pipe's actual wall thickness can be expressed in terms of the pipe's diameter ratio (DR), Equation 1 can be rearranged as shown in Equation 2. The resultant net buoyancy force can be determined from the pipe's actual outside diameter, its DR (or SDR), the extent to which the pipe is filled with air, the density of the water into which the pipe is submerged, and the densities of the pipe and of the liquid inside the pipe:

(2)
$$F_B = \left[0.00545 D_o^2 \rho_w\right]\left[4.24\frac{(DR-1.06)}{(DR)^2}\frac{\rho_p}{\rho_w} + \left(1-\frac{2.12}{DR}\right)^2(1-R)\frac{\rho_c}{\rho_w} - 1\right]$$

WHERE

F_B **= buoyant force, lbs/foot of pipe**

D_o **= external diameter of pipe, in**

D_R **= pipe dimension ratio, dimensionless**

R **= fraction of inner pipe volume occupied by air**

ρ_w **= density of the water outside the PE pipe, lbs/cu. ft**

ρ_p **= density of the pipe material, lbs/ cu. ft.**

ρ_c **= density of pipe contents, lbs/ cu. ft.**

The derivation of Equation 2 is presented in Appendix A-1. The reader is advised that Equation 2 does not consider lift forces that can result from water currents; refer to Appendix A-2 for further assistance with this topic.

A more succinct way of expressing the principle embodied in Equation 2 is as follows:

(3) $F_B = W_{DW}\,[\text{“K”}]$

WHERE

W_{DW} **= 0.00545** $D^2{}_0\rho_w$

Stated in words, the resultant buoyant force (F_B) is equal to the potential theoretical buoyant force (W_{DW}) times a buoyancy reduction factor (“K”) that takes into account inner pipe volume, degree of air filling and the densities of the pipe and the liquid inside the pipe.

The manner by which the buoyancy reduction factor “K” is affected by a pipe's DR and the extent to which its inner pipe volume is filled with air, R, is indicated by the calculation results reported in Table 1. The values in this table have been computed based on the following densities: 62.3 lbs/ cu. ft for water both inside and outside the pipe, and 59.6 lbs/cu. ft for the PE pipe material. Using these K-values for approximation of the net buoyant force of a submerged pipeline in which a portion of the line is occupied by air greatly simplifies the calculations involved.

TABLE 1
Typical values of "K" in equation 3.0

"K" is the fraction of maximum potential buoyancy. The exact value of "K" is determined by the particular combination of pipe diameter ratio (SDR), pipe material and liquid densities and the extent (R) to which a PE pipe is filled with air*

Pipe SDR	Value of "K" as a function of R, the fraction of inner pipe volume that is occupied by air					
	R = 0.10	R = 0.15	R = 0.20	R = 0.25	R = 0.30	R =1.0 (100% Air)
9	-0.078	-0.107	-0.136	-0.166	-0.195	-0.604
11	-0.081	-0.113	-0.146	-0.178	-0.211	-0.667
13.5	-0.084	-0.119	-0.155	-0.190	-0.226	-0.723
17	-0.087	-0.125	-0.163	-0.202	-0.240	-0.776
21	-0.089	-0.130	-0.170	-0.210	-0.251	-0.817
26	-0.091	-0.133	-0.176	-0.218	-0.260	-0.850
32.5	-0.093	-0.137	-0.180	-0.224	-0.268	-0.879

* The "K" values in this table have been computed using Equation 2 and based on the following assumptions: a density of 62.3 lbs/cu ft for water outside and inside the pipe and 59.6 lbs/cu ft for the PE pipe material. The minus sign before each resultant value of "K" indicates a net upward, or buoyant force.

Step 3b Determining the Maximum Weighting That Still Allows PE Pipe To Float

When a PE pipe that is completely filled with air is weighted so that the submerged weighting is equal to W_{DW} (the weight of the water that is displaced by the outer volume of the pipe) times the appropriate value of "K" (e.g., the value given in the last column of Table 1), that pipe achieves neutral buoyancy – it neither sinks nor floats. Therefore, "K" represents the fraction of pipe displacement that, when counteracted by the placement of external weighting on the pipe, results in neutral buoyancy. With the objective in mind of facilitating a marine installation by the floating of a PE pipe so that it may readily be stored above water and then towed and maneuvered to its intended location, the weighting that is attached to the pipe needs to be limited to an amount that still allows an air-filled pipe to freely float on top of the water. To this end, the practice is to limit the weighting of an air-filled PE pipe to about 85% of the pipe displacement times the "K" value that corresponds to that pipe's DR and the densities of the pipe material and the water, for example, the "K" values reported in the last column of Table 1. This practice results in the limiting of the weighting of an air-filled pipe that is to be installed by the "float-and-sink" method to a maximum that can vary, depending on the pipe's DR, from about 57 to 75% of the pipe's displacement.

Step 3c Determining the Required Minimum Weighting for the Anchoring of a Submerged Pipe in its Intended Location

Fortunately, as indicated by analysis and confirmed by experience[1,2], in most cases

a weighting of 25 to 50% of the pipe displacement is quite sufficient to maintain a properly anchored submerged PE pipe after it has been filled with water. The lower weighting has been found satisfactory in cases, like in lake crossings, where current and wave action are relatively mild, while the larger weighting is used in sea installations where sea actions are stronger. However, even for pipes that are exposed to normal sea conditions close to the shore, it has been found that a weighting of about 70% of the pipe displacement is quite satisfactory[1]. As indicated by the values shown in Table 1, this extent of weighting still allows most PE pipes to float when air-filled.

In an article summarizing the state of the art in utilizing plastics pipe for submarine outfalls, Janson[3] reports that, based on past practical experience and theoretical studies, a 40-inch diameter PE ocean outfall line was installed in Sweden where, for depths greater than 40 feet, the pipe was weighted to 25% of its displacement; and in the surf zone, where the waves break and the water depth is about 10 feet, the loading was increased to 60% of the displacement. Closer to the shore, where wave action is at its strongest, it is common to protect the pipe by trenching it. In respect to trenched pipe, Janson also reports that, when a trench is refilled with fine-grained soil, the buried pipe can sometimes float from the trench, apparently a reaction resulting from the fluidization of the fill by strong wave action. This reference further reports that the possibility of floating from fine-grained backfill can be avoided by weighting the pipe to at least 40% of its displacement.

Calculation techniques have been developed for the determination of the required weighting of plastic pipes depending on anticipated current and wave action. A brief overview of the technical considerations upon which these calculations are based is included in Appendix A-2. References for further information are also provided.

In cases where it is indicated that the pipeline, or certain sections of the line, should be weighted to a greater extent than that which allows the pipe to float while filled with air, the attachment of the required ballast weights can be conducted in two stages: preliminary weighting is conducted so as to still allow the pipe to be floated into position, and then the additional required weights are added where required after the completion of the submerging of the pipe. Another option is to temporarily increase the pipe's buoyancy by the use of empty tanks or drums, or large blocks of rigid plastic foamed material that are then released as the pipe is being submerged. A further option, which is illustrated in Figure 1, is to attach the required ballast weights onto the pipe from a barge from which the pipe is slid to the bottom by means of a sled that has been designed to ensure that the bending of the pipe is less than that which might risk buckling (See the discussion on pipe submersion).

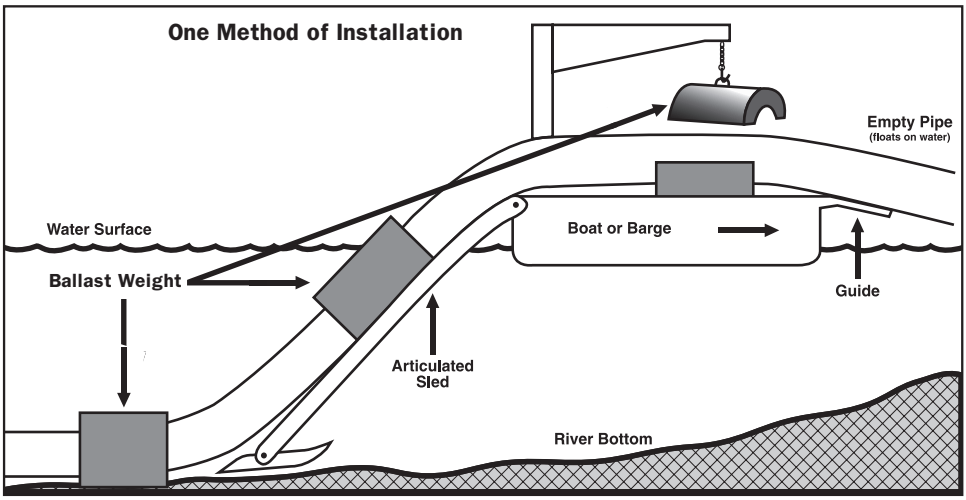

Figure 1 Submerging a heavily weighted pipe from a barge

Step 3d Ensuring that the Required Weighting Shall Not Be Compromised by Air Entrapment

As suggested by the "K" values in Table 1 that apply to pipes that are partially filled with air, even a modest amount of air entrapment can result in a lift force that can significantly reduce the quality of pipe anchorage. For example, if a pipeline is weighted to 25% of the water it displaces and in a section of that pipeline enough air accumulates to occupy just 10% of the pipe's inner volume, the lift produced by that amount of air will reduce the effective weighting in that portion of the pipeline to about only 15% of the pipe displacement. Such reduction is sure to compromise the stability of that pipe section against wave and current actions. Accordingly, one important objective in the design of the piping system to prevent the entrance and accumulation of air in all portions of the submerged section. In outfall systems, one effective means for achieving this objective is to utilize a surge or "drop" chamber into the system design, as illustrated in Figure 2. Another precautionary measure is to ensure that there are no localized high points along the submerged pipeline that could accumulate air or gases, particularly during periods of low or no flow rate.

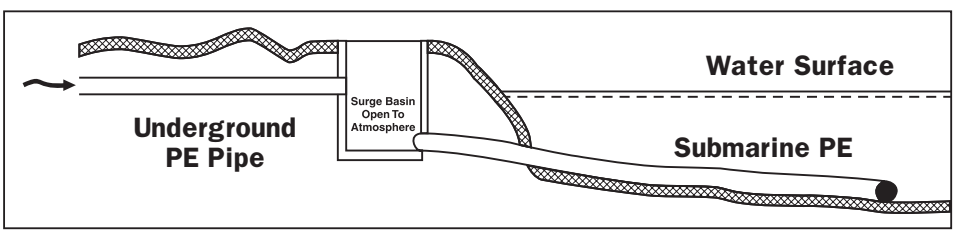

Figure 2 A surge chamber may be used to prevent air from entering a pipeline

In cases where the possibility of some accumulation of air or gas – which may be given off by chemical reactions – cannot be avoided, or where the line may at some time be emptied, it is necessary to add enough ballast weighting to offset the additional negative buoyancy so as to always hold the pipe in its intended location.

Step 3e Determining the Spacing and the Submerged Weight of the Ballasts To Be Attached to the Pipe

The objectives for limiting the spacing between ballast weights are essentially the same as those for establishing the support spacing requirements for above-ground suspended pipelines. In both cases the pipes are subject to a distributed loading – in the case of submerged pipelines, by the combined effect of current, lift and wave actions. The objective of the design is to limit resultant pipe deflection so that the resultant maximum fiber bending stresses and strains are within safe limits. An additional reason for limiting deflection in submerged pipelines is to reduce the chances of forming pockets in which air or gas can accumulate. The lift created by air-filled pockets can, if large enough, compromise the quality of the anchoring of the submerged pipe. Information on conducting the required calculations and on the appropriate limiting values for bending stress and strain is included in the chapter on design. Because of the concern of trapping air, support spacing for submerged pipes is normally delimited by allowable pipe deflection – considerably greater deflection would generally be permitted under the criteria of maximum bending stress or strain.

Listed in Table 2 are commonly used ballast spacings. To satisfy the objective for minimizing air entrapment, the spans in this table are somewhat shorter than for pipes that are suspended above ground. An added benefit of shorter spans is that they better distribute anchoring loads on the sea bottom, which often offers only moderate load bearing capacity. Additionally, these shorter spans minimize the chance of pipe shifting, help smooth out the submersion process and they lead to ballasts that are more manageable both in size and in weight.

TABLE 2
Commonly Used Values for the Spacing of Ballasts

Nominal Pipe Diameter, in	Approximate Spacing (L), ft
Up to 12	5 to 10
Over 12, up to 24	7.5 to 15
Over 24, up to 63	10 to 20

Source: AWWA M55, PE Pipe – Design and Installation, Chp 8: Installation, Denver, Colorado, USA

The required submerged weight of the ballasts can be determined from the following:

(4) $$B_W = W_S \times L$$

WHERE

B_W **= weight of ballast in water, lbs**

W_S **= required submerged weighting by ballasts, lbs per foot**

L **= center to center spacing between ballasts, feet**

The resultant dry weight of the ballast depends on the density of the ballast material as compared to that of the water into which the ballast is to be submerged:

(5) $$B_A = B_W \frac{\rho_B}{\left(\rho_B - \rho_W\right)}$$

WHERE

B_A **= weight of ballast in air, lbs**

ρ_B **= density of ballast, lbs/cu. ft (~144 lbs/cu ft for plain concrete, ~ 150 for reinforced)**

ρ_W **= density of water, lbs/ cu ft (~62.3 lbs/cu ft for fresh water, ~64.0 lbs/cu ft for sea water)**

Since the weight of a ballast cannot be closely predicted or readily adjusted, it is more practical to tune in the final weighting to the required value by adjusting the distance between ballasts of known weight. To this end the following formula, derived by combining Equations 4 and 5, may be used:

(6) $$L = \frac{B_A}{W_S} \frac{\left(\rho_B - \rho_W\right)}{\rho_B}$$

Step 3f Design and Construction of Ballast Weights

To prevent cracking of ballasts when handling, tightening and moving PE pipe, they are typically made of suitably reinforced concrete. Ballasts can be made to different shapes, although a symmetrical design such as round, square, or hexagonal is preferred to avoid twisting during submersion. Flat-bottomed ballasts are preferred if the submerged piping is likely to be subjected to significant currents, tides or wave forces because they help prevent torsional movement of the pipe.

Also, when such conditions are likely to occur, the ballasts should place the pipeline at a distance of at least one-quarter of the pipe diameter above the sea or river bed. The lifting force caused by rapid water movement that is at a right angle to a pipe that rests on, or is close to a sea or river-bed is significantly greater than that which acts on a pipe that is placed at a greater distance from the bed. This means that ballasts designed to give an open space between the pipe and the bed will give rise to smaller lifting forces.

For example, in accordance with the calculation procedure developed by Janson (See Appendix A-2), the lifting force that develops on a 12-in PE pipe that is resting directly on a sea bed and that is at an angle of 60° to the direction of a strong current that is flowing at a rate of about 10 feet per second is approximately 100 lbs per foot. When this pipe is raised above the sea bed so that the space between the bottom of the pipe and the sea bed is one-quarter of the pipe's outside diameter, the lifting force is reduced to about 25 lbs per foot.

The ballasts should comprise a top and bottom section that, when mated together over a minimum gap between the two halves, the resultant inside diameter is slightly larger than the outside diameter of the pipe. This slightly larger inside diameter is to allow the placement of a cushioning interlining to protect the softer PE pipe from being damaged by the hard ballast material. Another function of the interlining is to provide frictional resistance that will help prevent the ballasts from sliding along the pipe during the submersion process. Accordingly, slippery interlining material such as polyethylene film or sheeting should not be used. Some suggested interlining materials include several wraps of approximately 1/8-in thick rubber sheet or approximately ¼-in thick neoprene sponge sheet.

The purpose of the minimum gap between the two halves of the ballasts is to allow the two halves to be tightened over the pipe so as to effect a slight decrease in pipe diameter and thereby enhance the hold of the ballast on the pipe.

Additionally, experience has shown that in certain marine applications where tidal or current activity may be significant, it is feasible for the pipe to "roll" or "twist". This influence combined with the mass of the individual ballasts may lead to a substantial torsional influence on the pipe. For these types of installations, an asymmetric ballast design in which the bottom portion of the ballast is heavier than the upper portion of the ballast is recommended. Typical design considerations for this type of ballast are shown in Appendix A-3.

Suitable lifting lugs should be included in the top and bottom sections of the ballasts. The lugs and the tightening hardware should be corrosion resistant. Stainless steel strapping or corrosion-resistant bolting is most commonly used. Bolting is preferable for pipes larger than 8-in in diameter because it allows for post-tightening prior to submersion to offset any loosening of the gripping force that may result from stress-relaxation of the pipe material.

Examples of various successfully used ballast designs are shown in Appendix A-3.

Figure 3 Two-piece Concrete Anchors in Storage at Marine Job-Site

Step 4 Selection of an Appropriate Site for Staging, Joining and Launching the Pipe

The site for staging, joining and launching the pipe should preferably be on land adjacent to the body of water in which the pipeline is to be installed and near the point at which the pipe is to enter the water. Also, the site should be accessible to land delivery vehicles. If these requirements are not easily met, the pipe may be staged, joined and weighted at another more accessible location and then floated to the installation site. Long lengths of larger diameter PE pipe have been towed over substantial distances. However, considerable precautions should be exercised for insuring the stability of the towed materials in light of marine traffic, prevailing currents or impending weather considerations.

To facilitate proper alignment of the pipe-ends in the fusion machine and to leave enough room for the attachment of the ballast weights, the site near the water should be relatively flat. It is best to allow a minimum of two pipe lengths between the fusion joining machine and the water's edge. The site should also allow the pipe to be stockpiled conveniently close to the joining machine.

The ground or other surface over which the pipe is to be moved to the water should be relatively smooth and free of rocks, debris or other material that may damage the pipe or interfere with its proper launching. When launching a pipe with ballast weights already attached, provision should be made for a ramp or a rail skidway arrangement to allow the ballasts to move easily into the water without hanging up on the ground. As elaborated under the launching step, the end of a pipe that is moved into the water needs to be sealed to prevent water from entering and, thereby, compromising its capacity to float freely.

Step 5 Preparing the Land-to-Water Transition Zone and, When Required, the Underwater Bedding

At some point in time before the start of the submersion procedure, usually before the pipe is launched, a trench needs to be prepared in which to place the pipe between the point where it leaves the shore and the first underwater location beyond which the pipe is completely submerged without the need for external protection. The trench needs to be deep and long enough to protect the pipe from wave action, tidal scour, drifting ice and boat traffic. Special care should be employed in the design and construction of the land-to-water transition in ocean outfalls where occasional rough seas can result in very strong waves and in the scouring of the material below and around the pipe.

Unless weighted to a relatively high extent, say to at least 40% of the pipe displacement, a pipe lying in a land-to-water transition trench that has been filled with fine silt or sand could float up when that zone is subjected to strong wave action. One method of controlling this tendency would be to utilize increased weighting via enhanced ballast design. Alternatively, the submerged pipe could be placed on a bed of prepared backfill and subsequently surrounded by graded material in accordance with ASTM D2774, Standard Practice for Underground Installation of Thermoplastic Pressure Pipe. This ASTM standard provides that plastic pipe installed underground will be bedded and backfilled using material with a particle size in the range of ½" to 1 ½" depending on the outside pipe diameter. However, it may be necessary to place a layer of even larger particle sized fill (1 ½" to 4") over the graded material to avoid movement of the stone backfill in some tidal zones or areas of strong current activity. Protection and stabilization of the pipe installation may be further enhanced by the placement of a 1 to 2 foot cover of blast rock over the completed installation.

With regard to the preparation of the underwater support generally, no dredging of filling needs to be carried out because the ballasts act to keep the pipe above the bottom material. The principal requirement is that the pipe should not rest or come in contact with large stones. To this end, larger stones that project above the bottom and that could come in contact with the pipe should be removed, as well as those that lie within about 3 pipe diameters on either side of the pipe.

Step 6 Assembly of Individual Lengths of PE Pipe Into Long Continuous Lengths

The butt fusion of individual lengths into a long string of pipe should be conducted by trained personnel and by means of appropriate equipment. The heat fusion parameters – e.g., temperature, interfacial pressure, heating and cooling times – should be as recommended by the pipe manufacturer for the particular pipe material

and the joining conditions, including outdoor temperature and wind. (See Chapter 9 on PE Joining Procedures.)

Upon the completion of the heat fusing of an added individual length to the pipeline, the resultant longer pipe string is further moved into the water. As discussed elsewhere, the pipe should always be moved to the water using suitable mechanical equipment that will cause no damage to the pipe or to the pipe ends.

Ballast weights can be mounted before the pipe string reaches the water. If circumstances make it more practical, the ballasts can also be attached on the floating pipe from a floating barge by a scheme such as illustrated in Figure 4.

Step 7 Mounting the Ballasts on the Pipe

Since the process of heat fusing a new pipe section on a string of pipe usually takes less time than the attaching of ballasts, the later procedure can be quickened by increasing the number of work stations. It is also helpful to stockpile the ballasts adjacent to each work station. Adequate lift equipment needs to be on hand to move the ballasts from the stockpile to the pipe location and to lift the pipe to allow the ballasts to be positioned under it. This equipment can also be used to lift and pull the pipe into the water. A suitable ramp or skidway should be provided to move weighted pipe into the water with a minimum of drag. (See discussion on launching the pipeline.)

For mounting ballasts on the floating pipe it is necessary to have low-profile equipment such as a barge or raft that is of sufficient size to accommodate the required lifting equipment and to carry sufficient ballasts to allow for efficient operation. In this method the barge is brought alongside the floating pipe, the pipe is lifted to install one or more ballasts, and after their installation the pipe is returned to the water and a new section is moved onto the barge or the barge is advanced along the floating string of pipe. In either case, the working surface or platform of
the barge should be as close as possible to the water to reduce the need for a high lifting of the weighted pipe.

The steps involved in the mounting of ballasts include the following:

1. The placing of the protective/friction inducing material around the pipe. This can be done by first placing a pad over the lower half of the ballast and then placing a similar pad over the top of the pipe before the upper half of the ballast is lowered into position.
2. Lifting the pipe and positioning the lower half of the ballast under the pipe
3. Lowering the pipe so that it sits in the lower half of the ballast

4. Positioning and then lowering the upper half of the ballast so it sits on top of the pipe
5. Applying the strapping or tightening the bolts so that the ballasts are held fast to the pipe. (Note: before submersion, retightening of the bolts may be necessary to overcome any loss of gripping that may result from the stress-relaxation effect).

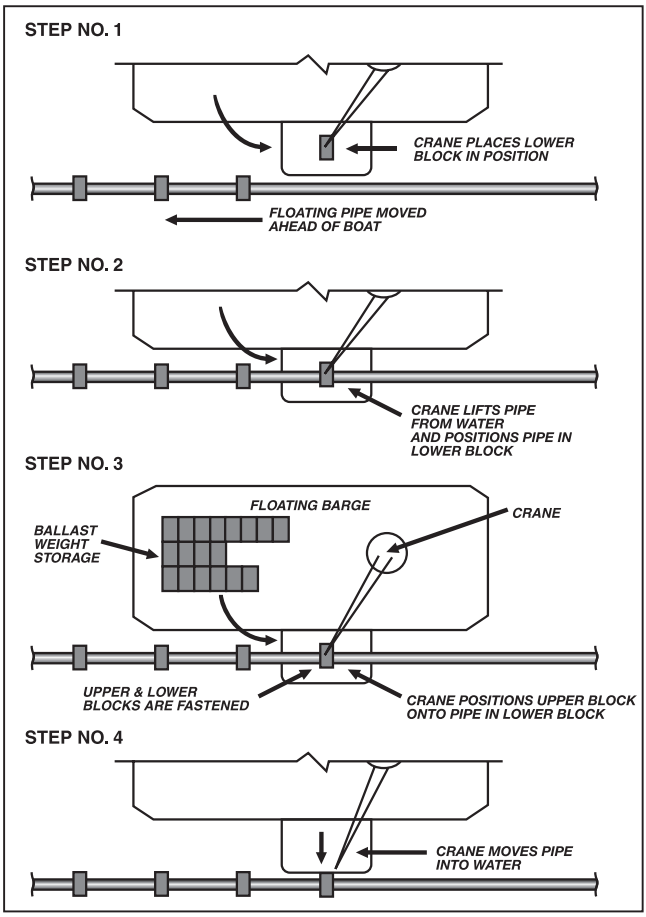

Figure 4 Installation of ballast weights from a raft or barge

Step 8 Launching the Pipeline into the Water

As previously cautioned, pipe that is launched into the water needs to have its ends closed, or its outlets located sufficiently high above the water, to prevent any water from entering the pipe. When the pipe is launched in the form of shorter strings of pipe that will later be joined to each other to produce the required overall length of submerged pipe, each separate section needs to have both ends sealed to

prevent water from entering. In this respect, effluent outfall lines require special consideration.

Effluent outfalls usually terminate in one or more diffuser sections. Diffusers can be of different designs such as a "Y" or "T" outlet, a pipe length in which holes have been drilled on top of the pipe within 10 and 2 o'clock, or a pipe length onto which vertical risers consisting of short sections of smaller diameter PE pipe have been fused. Diffusers are often designed for connection to the pipe by means of flange assemblies. The connection can be made prior to launching, or by divers after the pipeline has been submerged. When a diffuser is attached prior to launching, it is necessary to float the diffuser higher up over the water by means of some additional buoyancy. This is necessary to prevent water from entering the pipe through the diffuser openings. This additional buoyancy is released as the pipe is sunk into position.

Extreme care should be taken in the submersion of a marine line with an engineered diffuser attached to the pipeline which is being sunk in place. The sinking process can create considerable stresses on the fittings that may be inherent to the design of the diffuser itself such as flanges, tees and/or other mechanical connections. A preferred method when placing a highly engineered diffuser into an HDPE marine pipeline is to first sink the flanged effluent pipe and then submerge the diffuser separately in easily controlled segments which may be connected to the main effluent pipe underwater using qualified diving contractors.

A pipe end that does not terminate in a diffuser section is best closed against entering water by attaching a blind flange assembly. The flange assembly consists of a PE stub end that is butt fused to the pipe end on which has been bolted a slip-on metal flange. A number of required tapped holes are drilled on the blind flange so as to allow for the installation of valves and other fittings required to control the sinking operation. (See the section on submersion of the pipeline.)

Figure 5 Unballasted PE Pipeline Being Floated Out to Marine Construction Barge Where Ballast Weights are Installed

Pipe with attached ballast weights should be moved into the water by means of a ramp or skidway arrangement that allows the ballasts to move easily into the water without hanging up on the ground. The ramp or skidway must extend sufficiently into the water so that when the pipe leaves this device the ballast weight is fully supported by the floating pipe. Pipe without ballast weights may be moved over the ground provided it is free of rocks, debris or any other material that may damage the pipe. When this is not practical, wooden dunnage or wooden rollers may be placed between the pipe and the ground surface.

The pipe should be moved using suitable equipment. The pipe may be moved by lifting and then pulling it using one piece of equipment while using another piece of equipment to simultaneously push the pipe from its inboard end. PE pipe should only be lifted using wide-band nylon slings, spreader slings with rope or band slings, or any other means that avoids the development of concentrated point loading. Under no conditions should the flange assemblies be used to pull the pipe.

Prior to the launching of the pipe into the water, a strategy should be worked out to control the floating pipeline as it moves into the water and to store it away from navigational traffic until such time as the entire length is ready for submerging. For this purpose, suitable marine equipment – such as boats that have adequate tugging power and maneuverability – may need to be on hand. Other means for controlling the pipe can be a system of heavy block anchors that are positioned on either side of the proposed site into which the pipe will be submerged. In the case of river crossings, a system of guide cables that are anchored on the opposite shore can serve to control the position of the pipeline, particularly when the pipeline is subject to strong river flow.

In the case of river crossings when navigational traffic prohibits the float-and sink procedure, a "bottom-pull" procedure, illustrated in Figure 6, has been successfully used. When using this procedure, only sufficient ballast is added to the pipe to ensure that the pipe follows the river bottom as it is winched from one shore to the other. After the completion of the "bottom-pull," additional ballast can be added or the pipeline can be adequately backfilled to produce the required anchoring and to offset any lift that may be created by currents or river flow.

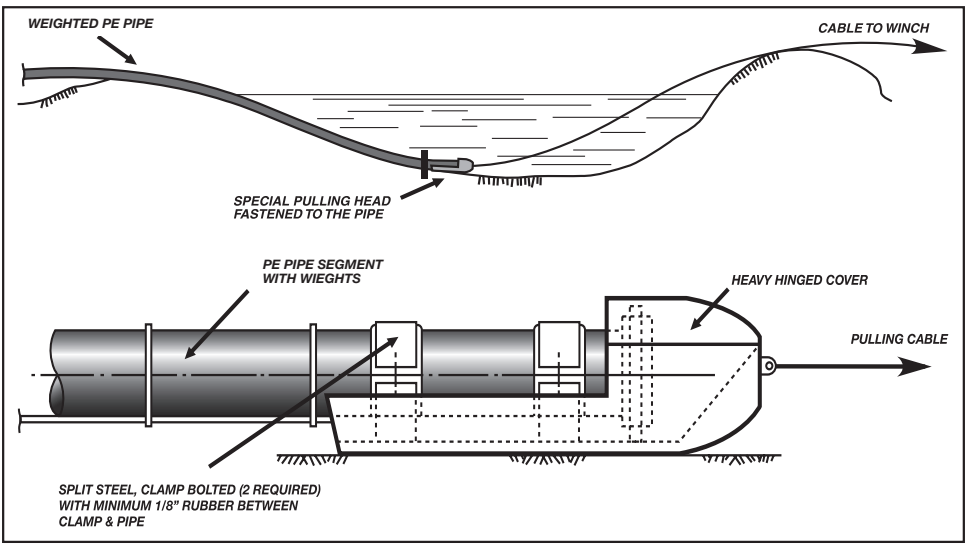

Figure 6 "Bottom-Pull" Installation of PE Pipe

Step 9 Submersion of the Pipeline Using the Float-and-Sink Method

To prepare the pipe for submersion, it is first accurately positioned over its intended location. The sinking operation basically consists of the controlled addition of water from the on-shore end of the pipe and the release of the entrapped air from the opposite end. The sinking is conducted so that it starts at the shore where the pipe enters the body of water and then gradually progresses into deeper waters. To achieve this, an air pocket is induced by lifting the floating pipe close to the shore. As the water is allowed to enter the pipe from the shore side, the added weight causes this initial air pocket to move outward and the intermediate section of pipe between the air pocket and the shore end to sink. As additional water is added, this pocket moves to deeper waters causing the sinking to progress to its terminal point in the body of water. This controlled rate of submersion minimizes pipe bending and it allows the pipeline to adjust and conform to the bottom profile so that it is evenly supported along its entire length (See Figure 7).

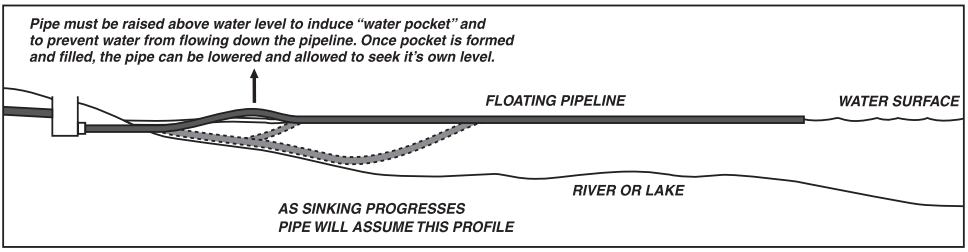

Figure 7 An induced water pocket initiates the submersion of the pipe and, as the pocket enlarges, it allows the submerging to gradually progress forward

A potential risk during the submersion operation is that, when the pipe sinking occurs too quickly, the bending of the pipe between the water-filled and air-filled portions may be sharp enough to risk the development of a kink, a form of localized pipe buckling. As a pipe is bent, its circumferential cross-section at the point of bending becomes increasingly ovalized. This ovalization reduces the pipe's bending moment of inertia, thus decreasing the bending force. Upon sufficient ovalization, a hinge or kink can form at the point of maximum bending an event that also leads to a sudden reduction of the bending force. Since the formation of a kink impedes the submersion process and can also compromise the pipe's flow capacity and structural integrity – in particular, the pipe's resistance to collapse under external pressure – it is essential that during submersion the bending of the pipeline be limited to an extent that will not risk the formation of a localized kink. The pipe bending radius at which buckling is in risk is given by the following expression:

(7)
$$R_b = D_o \frac{(DR - 1)}{1.12}$$

WHERE

R_b **= bending radius at which buckling can be initiated, in**

D_o **= outside pipe diameter, in**

DR **= pipe diameter ratio = average outside diameter divided by minimum wall thickness, dimensionless**

Janson's relationship for determination of minimum buckling radius (Eq. 7) was derived on the basis of a maximum pipe deflection (ovalization) due to bending of the pipe of 7% and a maximum strain limit in the pipe wall of 5%. In actuality, the short term strain limit for modern polyethylene pipe materials is somewhat higher, on the order of 7-10%. Further, we know that these pipe materials are capable of long-term service at higher degrees of ovalization in buried pipe installations. (Please refer to Chapter 6 of this Handbook.) As a result, the values presented in Table 3 are considered conservative guidelines for the short-term bending radius of polyethylene pipe during submersion of most marine pipelines. The designer may

want to utilize a higher minimum bending radius to compensate for additional factors such as extremely strong currents, tidal activity, prevailing marine traffic, frequency of ballast placement, or other installation variables associated with a specific installation.

TABLE 3
Pipe Diameter Multipliers for the Determining of Minimum Bending Radii

Pipe DR	Multiplier*
11	8.9
13.5	11.2
17	14.3
21	17.8
26	22.3
32.5	28.1

* The minimum buckling radius of a pipe, in inches, is equal to the pipe's outside diameter, in inches, times the listed multiplier

It is essential that the water be introduced into the pipe at a controlled rate. This is done to ensure that the submersion process occurs at a rate that does not result in excessive localized pipe bending that could buckle the pipe. It also allows the pipe to settle properly on the bottom – thus avoiding any bridging between high spots which may make the pipe more vulnerable to movement when subjected to strong currents. Experience has shown that submerging the pipe at a rate in the range of about 800 to 1500 feet per hour has been found to be adequate for most cases. While the pipe is in the bent condition, long stoppage of the submersion procedure must be avoided. Consult with the pipe manufacturer and design engineer for specific submersion techniques for individual installations.

The risk of buckling can be minimized by applying a suitable pulling force during the submerging, such as illustrated by Figure 8.

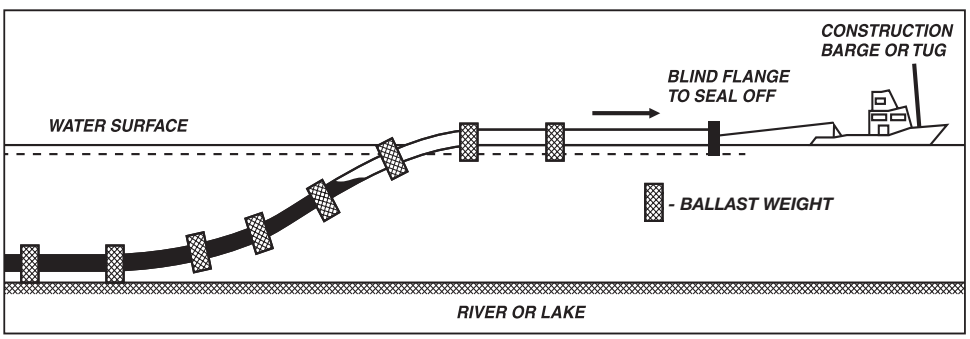

Figure 8 Pulling the pipe during submersion is a means for avoiding excessive bending that could risk buckling of the pipe

As water is being added at the shore-end of the pipe, air must be allowed to escape from the opposite end. In the case of outfall pipelines that terminate in one or more diffuser sections, the air is released through the diffuser outlets. When a pre-attached diffuser is used, it is necessary to support it with some additional buoyancy as a precaution against the water entering the pipe and causing that section of the pipeline to sink prematurely. Extreme care should be taken in the ballasting and submersion of elaborate diffuser systems that are sunk in concert with the main effluent pipe as the submersion process can create significant stresses on the tees, elbows or other fittings used in the design of the diffuser system. The preferred method is to submerge the flange or valved main effluent pipe and the diffuser separately and join the two sections underwater using qualified diving contractors.

When the end of a pipe that is being submerged terminates with a flange connection, air release can best be accomplished by installing a valved outlet in the blind flange outlet. To ensure that water will not enter through this outlet, a length of hose may be connected to the outlet, and the free end is held above water on a boat or by means of a float. After the completion of the submersion, a diver can remove the hose.

Should a problem be encountered during the submersion, the availability of a valved outlet on the outboard end of the pipeline allows the sinking procedure to be reversed. Compressed air can be pumped into the submerged line to push the water out and thus allow the line to be raised. Because compressed air packs a lot of potential energy – which, when suddenly released through a failure of a piping component, could present a serious safety hazard – the rule of thumb is to limit air pressure to not more than one-half the pipe's pressure rating for water.

Under certain methods, such as the bottom-pull method that is described above, the necessary ballast to offset floatation during the installation of a water filled PE pipe can be of a temporary nature – for example, steel reinforcing bars that are strapped on the outside of the pipe. This temporary ballast can be removed after the installation of permanent anchoring. Permanent anchoring can consist of an appropriate quantity of stable backfill that is placed on pipe that has been installed in a trench, or it can consist of tie-down straps that are installed by augering or other procedures that result in the permanent anchoring of the pipeline. However, when considering an alternate means for anchoring a pipeline, it should be kept in mind that, as discussed earlier, a pipeline lying on the sea or river floor is subject to greater lift action by currents or waves than a pipeline that lies even a short distance above the bottom.

Step 10 Completing the Construction of the Land-to-Water Transition

After the pipeline has been submerged, the portion of the pipeline that has been lowered into a land-to-water transition trench should be backfilled with specified material and to the required depth of cover.

Post-Installation Survey

Upon completion of the installation of a submerged pipeline, it is advisable to have the complete line surveyed by a competent diver to ensure that:

- The pipeline is located within the prescribed right-of-way
- The ballasts holding the pipeline are all properly sitting on the bottom contour and that the line is not forced to bridge any changes in elevation
- The pipe is not resting on any rocks, debris or material that could cause damage
- Any auxiliary lines, such as hoses, ropes, buoyancy blocks or any other equipment used during the installation has been removed
- Where required, the pipe has been backfilled and the backfilling was done properly
- All other installation requirements established by the designer for the subject application have been complied with.

Other Kinds of Marine Installations

Because of its flexibility, light-weight and toughness PE piping has also emerged as a choice material for other types of marine applications. The basic design and installation principles described above for the "float-and-sink" method are, with some modifications, also valid for other types of marine applications. A brief description of some other kinds of marine applications is presented in the paragraphs that follow.

Winter Installations

Where ice conditions permit, PE pipe may be submerged from the surface of a frozen lake or river. After a long pipe length is assembled by means of heat fusion it can be easily pulled alongside the right-of-way. The heat fusion process needs to be performed in an adequately heated tent, or other shelter, to ensure fusion joint quality. Once the heat fusion has been completed, the ballast weights can be mounted. An ice trench is then cut with a saw, the ice blocks are moved out of the way and the pipeline is pushed into the trench. The submersion is carried out in accordance with the procedure previously described.

Installations in Marshy Soils

Installation of pipe in marshy or swampy soils represents one of the most demanding applications for any design engineer. Generally, marshy soils do not provide the firm and stable foundation that is required by rigid, more strain sensitive traditional piping materials.

Due to its flexibility and butt fusion joining technology, PE piping can readily adapt itself to shifting and uneven support without sacrifice of joint integrity. As soil conditions vary, the PE pipe can accommodate these irregularities by movement within the fluid-like soil envelope. Of course, care must be taken to consider any line, grade or external hydrostatic design requirements of the pipeline based on the operating conditions of the system. However, with these design aspects in mind, it is possible to utilize the engineering features of PE pipe to design a cost-effective and stable piping system that can provide years of satisfactory service in this highly variable environment.

In certain situations, the high water table that is characteristic of these soils can result in significant buoyant forces that may raise the pipe from the trench in which it has been installed. When this possibility presents itself, a ballast system may be designed using the same guidelines presented in this chapter which can prevent or minimize pipe flotation.

Water Aeration Systems

Smaller diameter submerged PE pipe, with small holes drilled into the top of the pipe has been used for the de-icing of marinas. Compressed air that bubbles out of these pipes raises warmer water that melts ice that forms on the water surface. When the system is operating, the submerged pipe is full of air, and the ballast weight design should be adequate to prevent the line from floating. Ballast also needs to be spaced frequently enough to minimize the upward deflection that results from the buoyancy force.

Dredging

PE piping is a natural choice for use in marine dredging operations. Its flexibility, combined with its light weight, buoyant nature and overall durability, provides for a piping material which has been successfully used for years in the demanding rigors of dredging operations. Generally, these types of applications require that the HDPE pipe be fused into manageable lengths that can be easily maneuvered within the dredge site. These individual lengths are then mechanically joined together using flanges or quick-connect type fittings to create a pipeline structure of suitable length for the project. As the dredge operation proceeds, pipe segments may be added or removed to allow for optimum transport of the dredge material.

Dredging operations can vary significantly in type of slurry, scale or operation and overall design. As such, a detailed analysis of dredge design using HDPE pipe is beyond the scope of this writing. However, the reader should note that as the particulate size and nature varies from project to project, it is possible to ballast the pipe so that it still floats and can be managed from the surface using tow boats or booms. This is accomplished by analysis of the composition of the dredge material and the design and attachment of suitable floats to the HDPE discharge or transport pipe.

Temporary Floating Lines

PE piping has also been used for temporary crossings of rivers and lakes. Its natural buoyancy allows a PE pipeline to float on or near the water surface. The principal design and installation requirement for floating line applications is to work out a system to maintain the pipe in its intended location when it is subject to currents, winds and wave action. To this end, cable restraints are generally used. The cables need to hold the pipe by means of stable collars that do not slip along the axis of the pipe and that cause no damage to the pipe material.

Conclusion

Modern HDPE piping materials are a natural choice for marine installations. The overall durability and toughness of these products, combined with the innovative and cost-effective installation methods that they facilitate, are compelling reasons for their use in effluent discharge systems, water intake structures and potable water or sanitary sewer force main marine crossings, as well as more temporary marine systems such as dredging operations.

The dependable butt fusion system of joining PE pipe, supplemented by the availability of a wide array of mechanical fittings, means that the design engineer has an abundance of tools available by which to design a leak-free piping system that lends itself to the most demanding marine installations. This same system of joining allows for the cost-effective installation of long lengths of pipe via the float and sink method, directional drilling or pull-in-place techniques. Utilizing the unique features of the PE piping system allows the designer to investigate installation methods that minimize the necessity of costly pipe construction barges or other specialized equipment. These same installation techniques may minimize the economic impact associated with marine traffic disruption.

This chapter provides an overall design perspective for some of the more typical applications of HDPE pipe in marine environments. Its intent is to provide the designer with a basic understanding of the utility that PE pipe brings to the designer of these challenging installations. More elaborate design investigation

and methodology may be required depending on the specifics of the project under consideration. However, through a basic understanding of the benefits of PE pipe in marine installations and a fundamental understanding of the installation flexibility that they provide, it can be seen that PE pipe systems are a proven choice for modern, durable marine piping structures.

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Appendix A-1

Derivation of the Equation for the Determining of the Buoyant Force Acting on a Submerged PE Pipe (Equation 2 in the Text)

The first bracketed term in Equation 2, namely $[0.00545D^2_0\rho_W]$, is one commonly used form of the formula for obtaining a numerical value for the term W_{DW} in Equation 1, the weight of water that is displaced by the submerged PE pipe. This displaced weight is equivalent to the lift force acting on a submerged pipe that has an infinitely thin wall and that is completely filled with air. The sum of the three terms within the second set of brackets expresses the reduction of this potential lift force in consequence of the weight of the pipe (the first term) and that of its contents (the second term). As is evident from inspection of Equation 2, the extent to which the inner volume of a pipe is occupied by air (represented by the fraction R) exerts the more significant effect on resultant pipe buoyancy. Since a decrease in pipe DR (i.e., an increase in pipe wall thickness) results in a decrease in potential air volume space, a lower DR tends to reduce the potential buoyancy that can result from air filling.

1. The net buoyant (upward acting force) acting on a submerged PE pipe is:

(1) $$F_B = [W_p + W_c] - W_{DW}$$

WHERE

F_B **= buoyant force, lbs/foot of pipe**

W_p **= weight of pipe, lbs/foot of pipe**

W_c **= weight of pipe contents, lbs/foot of pipe**

W_{DW} **= weight of the water displaced by the pipe, lbs/foot of pipe**

2. W_p, the weight of pipe is:

$$W_p = V_p P_p$$

WHERE
V_p **= volume occupied by pipe material per foot of pipe**
P_p **= density of pipe material, lbs/ cu. ft**

Since $$V_p = \frac{\pi}{144} D_m t_a$$

WHERE
D_m **= mean pipe diameter of the pipe, in**
t_a **= average wall thickness, in**

And since $$DR = \frac{D_o}{t_m}$$

WHERE
D_o **= outside pipe diameter, in**
t_m **= minimum wall thickness, in**
Then, by assuming that the average wall thickness (t_a) is 6% larger than the minimum (t_m), it can be shown that:

(2) $$W_p = \frac{1.06\pi}{144}\left(\frac{D_o}{DR}\right)^2 (DR - 1.06)\rho_p$$

3. W_c, the weight of the pipe contents is equal to the volume occupied by the liquid inside the pipe times the density of the liquid:

$$W_c = V_L \rho_L$$

WHERE
V_L **= the volume occupied by the liquid, cu ft/linear ft**
P_L **= the density of the liquid inside the pipe, lbs/cu ft**
If the fraction of the inside volume of the pipe (V_I) is expressed as R and as the formula for the inside volume is as follows:

$$V_I = \frac{\pi D_I^2}{4}\frac{1}{144}$$

WHERE
D_I **= inside diameter of the pipe, in**

And also, since $D_I = D_o - 2t_a$ (where t_a *is* 1.06 t_m, as previously assumed) it can then be shown that:

(3)

$$Wc = \frac{\pi}{144}\frac{\rho_L}{4}\left[D_o\left(1-\frac{2.12}{DR}\right)\right]^2(1-R)$$

4. W_{DW}, the weight of the water displaced by the pipe is determined by means of the following formula:

(4)

$$W_{DW} = \frac{\pi D_o^2}{4}\frac{1}{144}\rho_W$$

WHERE
ρ_W = the density of the displaced water, lbs/cu ft

5. By substituting Equations 2, 3 and 4 into Equation 1, and by simplifying the resultant relationship, the following formula (Equation 2 in the text) is obtained:

$$F_B = \left[0.0054 D_o^2 \rho_W\right]\left[4.24\frac{(DR-1.06)}{(DR)^2}\frac{\rho_p}{\rho_w} + \left(1-\frac{2.12}{DR}\right)^2(1-R)\frac{\rho_c}{\rho_w} - 1\right]$$

Appendix A-2

Water Forces Acting on Submerged PE Piping

The following is a brief introduction to the technology for the estimating of the magnitude of the lateral forces that can act on a submerged pipe in consequence of water currents and wave action. As this technology is relatively complex and it is still emerging, the objective of this introduction is to provide basic information and references that can provide initial guidance for the proper design of PE piping for submerged applications. It is the responsibility of the designer to determine the design requirements and appropriate design protocol for the specific anticipated conditions and design requirements of a particular project. In addition to the information and references herein provided, the reader should consult the technical staff of PPI member companies for further information, including references to engineering companies that have experience in the use of PE piping for submerged applications.

Submerged pipes can be subject to lateral forces generated by currents or by wave action. A principal design objective is to ensure that the resultant lateral forces do not subject the pipe to excessive deflection, nor to fiber stresses or strains that could challenge the pipe material's capabilities. Thus, the capacity to estimate with some

reasonable accuracy the potential maximum lateral stresses to which a submerged pipe may be subjected is an important element for achieving a successful design.

Currents impinging on a submerged pipe can cause two principal forces: a drag force in the direction of the current; and a vertical force at right angles to the drag force. The magnitude of these forces depends on the angle between the direction of the current flow and the pipe. They are at their maximum when the current flow is at a right angle to the pipe. As this angle (Θ) is reduced, the resultant force is reduced by $\sin^2 \Theta$.

For the purpose of estimating the drag and lift forces that a current can exert on a submerged pipe, Janson developed the graphical solution that is herein reproduced as Figure A-2-1. This graph is applicable to the condition where the current velocity, expressed in feet per second, times the pipe diameter, expressed in feet, is equals to or is greater than 0.5 m^2/sec (2.7 ft^2/sec).

Janson's nomagraph is based on the assumption that certain design variables are known. These design variables are as follows:

D = external diameter of pipe, in meters (feet)
l = distance from the bottom, in meters (feet)
u_m = mean velocity of water, in m/sec (ft/sec)
h = depth of water, in meters (feet)
k = hydraulic roughness of the water bed, meters (feet)
Θ = angle between the direction of the current and that of the pipe, degrees
λ = ratio of l/h, dimensionless
= 0 for pipe placed on seafloor or bed of body of water

Janson determined that for values of D x U_m > 0.50 m^2/sec, a nomograph could be constructed which allowed for a relatively quick approximation of the drag and/or lift forces for which an underwater HDPE piping installation must be designed.

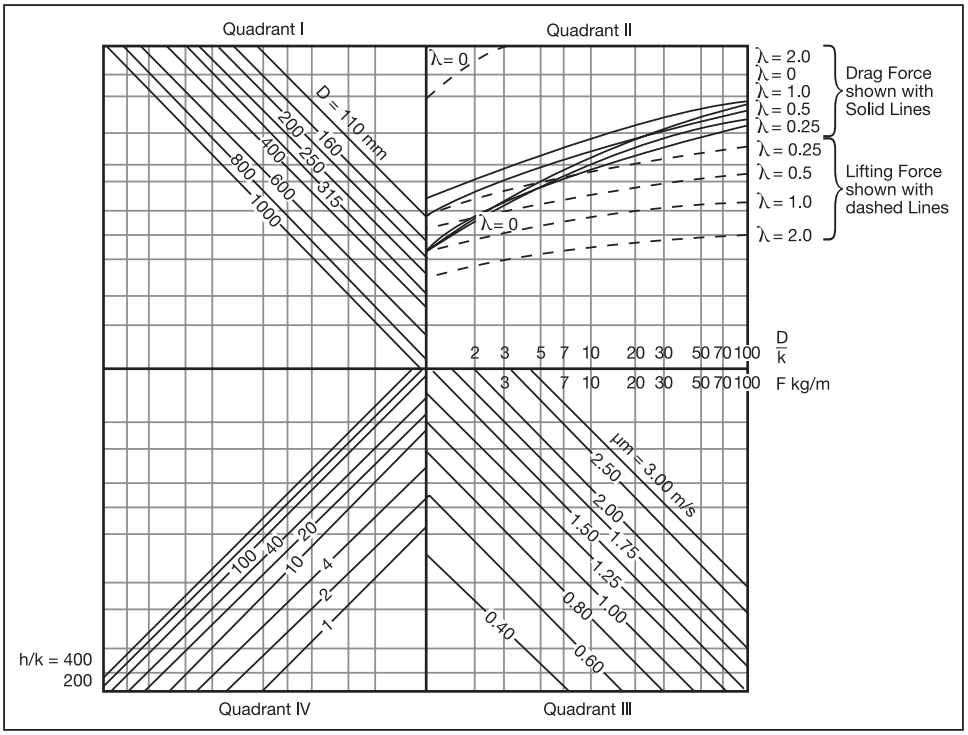

Figure A-2-1 Graph for the estimation of drag and lifting forces on underwater pipes when the flow rate of the current times the pipe diameter is 0.5 m^2/sec, or greater [4]

Consider the following example:

A 315 mm HDPE pipe is to be placed directly on the floor of a body of water that is flowing at approximately 3 m/sec and at 90 degrees to longitudinal axis of the pipe. The depth of the water is 10 meters and the pipe will be placed directly on a bed of gravel for which we will assume a hydraulic roughness of 10 cm.

Step 1 First, check to see if the nomograph is applicable

$$D \times u_m = 0.315 \text{ m} \times 3 \text{ m/sec} = 0.96 \text{ m}^2\text{/sec}$$

So, the nomograph can be utilized.

Step 2 Determine the two key dimensionless design ratios, D/k and h/k

GIVEN THAT

D **= 315 mm = 0.315 meter**

and

k **= 10 mm = 0.10 meter**

Then

D/k **= 0.315 m / 0.10 m = 3.2**

h/k **= 10 m / 0.10 m = 100**

Step 3 Determine the Drag Force

Utilizing the nomograph in Figure A-2-1, start at the horizontal axis between quadrant II and III. On the D/k axis locate the point 3.2 from the calculation in step 2. Draw a line vertically up to the solid curve (drag force) for $\lambda = 0$ (the pipe will rest on the bed of the body of water). Now draw a horizontal line from quadrant II into quadrant I to the line for diameter, in this case 315 mm. At the point of intersection with this line, draw another line downward to the line for h/k = 100 shown in quadrant IV. At that point of intersection, then draw another line horizontally back across to quadrant III to the line for flow velocity, in this example 3m/sec. From this point draw a line upward to the original axis and read drag velocity directly from nomograph. The result is 20 kg/m.

Step 4 Determine the Lift Force

Generally speaking, the lift force for a pipe laying on the floor of a body of water is eight times that of the drag force. In this case, the lift force generated is approximately 160 kg/m.

Alternatively, the lift force could have also been approximated from the nomograph by starting on the same axis between quadrant II and III and proceeding up to the dashed line for $\lambda = 0$ in quadrant II. The dashed line represent the curves for lift force relationships. From the intercept with the dashed curve for $\lambda = 0$, the procedure of is the same as that described for determination of the drag force from the nomograph.

Consider another example:

Now, using the scenario outlined in the preceding example, assume that the pipe is oriented in the water such that the angel of impact, θ, is 60 degrees.

Solution:

The revised angle of impact suggest that the drag force may be reduced by a factor, $\sin^2\theta$.

$$\text{Sin}^2\,\theta = \sin^2 60^\circ = 0.75.$$

Using this, we get a net drag force as follows:

$$\text{Drag Force}_{(90)} \times \text{Sin}^2\,\theta = 20 \text{ kg/m} \times 0.75 = 15 \text{ kg/m}$$

English Units

Janson's nomograph was originally published in metric units. However, the curves presented in quadrants II and IV are dimensionless. By converting quadrants I and III and the horizontal axis to English units then the nomograph may be used for pipe sized and installed accordingly. For ease of reference, Janson's nomograph is recreated using English units in figure A-2-2 below.

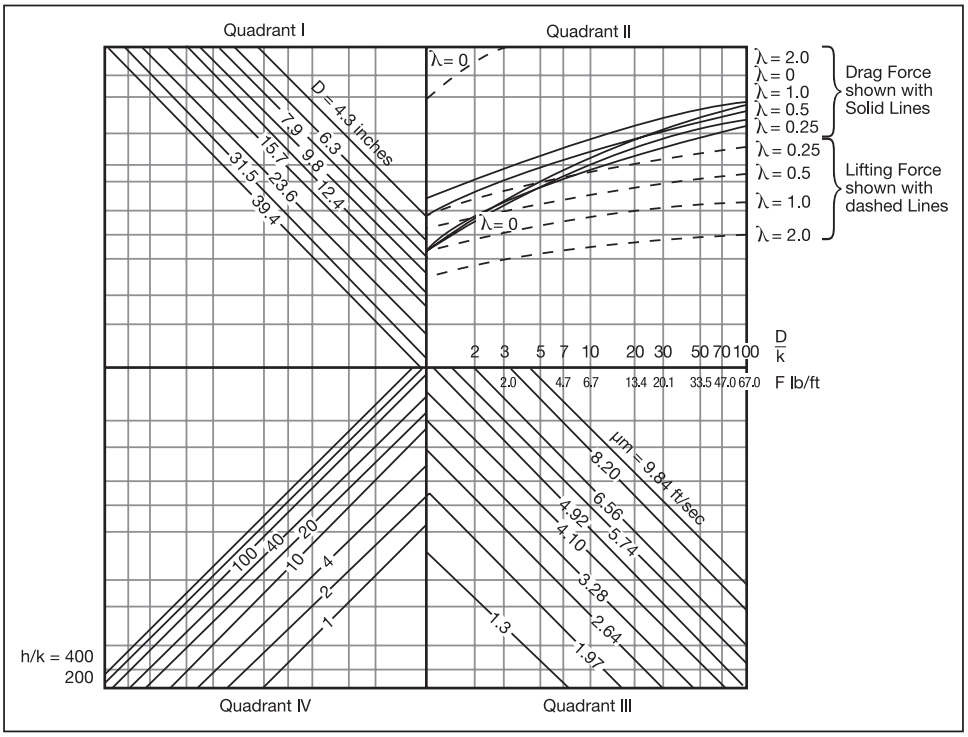

Figure A-2-2 Graph for the estimation of drag and lifting forces on underwater pipes when the flow rate of the current times the pipe diameter is 2.7 ft²/sec, or greater

Consider the previous example restated in English units

A 12″ IPS HDPE (325 mm) pipe is to be placed directly on the floor of a body of water that is flowing at approximately 9.8 ft/sec (3 m/sec) and at 90 degrees to longitudinal axis of the pipe. The depth of the water is 33 feet (10 meters) and the pipe will be placed directly on a bed of gravel for which we will assume a hydraulic roughness of 4 inches (10 cm).

Step 1 First, check to see if the nomograph is applicable

$$D \times u_m = 1 \text{ ft} \times 9.8 \text{ ft/sec} = 9.8 \text{ ft}^2/\text{sec} = 0.91 \text{ m}^2/\text{sec} > 0.50 \text{ m}^2/\text{sec}$$

So, the nomograph can be utilized.

Step 2 Determine the two key dimensionless design ratios, D/k and h/k

GIVEN THAT
D **= 12.75 inches = 1.06 foot**
and
k **= 4 inches = 0.33 foot**
Then
D/k **= 1.06/0.33 = 3.2**
h/k **= 33/ 0.33 m = 100**

Step 3 Determine the Drag Force
Utilizing the English version of the nomograph in Figure A-2-2, start at the horizontal axis between quadrant II and III. On the D/k axis locate the point 3.1 from the calculation in step 2. Draw a line vertically up to the solid curve (drag force) for $\lambda = 0$ (the pipe will rest on the bed of the body of water). Now draw a horizontal line from quadrant II into quadrant I to the line for diameter, in this case 12 inch. At the point of intersection with this line, draw another line downward to the line for h/k = 100 shown in quadrant IV. At that point of intersection, then draw another line horizontally back across to quadrant III to the line for flow velocity, in this example 9.8 ft/sec. From this point draw a line upward to the original axis and read drag velocity directly from nomograph. The result is 13.5 lbf/ft. The reader should keep in mind that this is only an approximation and is not intended to displace a more detailed engineering analysis of a specific marine installation design.

Step 4 Determine the Lift Force
As with the previous example, the lift force for a pipe laying on the floor of a body of water is eight times that of the drag force. In this case, the lift force generated is approximately 108 lbf/ft.

The lift force may be approximated from Figure A-2-2 by starting on the same axis between quadrant II and III and proceeding up to the dashed line for $\lambda = 0$ in quadrant II. The dashed line represent the curves for lift force relationships. From the intercept with the dashed curve for $\lambda = 0$, the procedure of is the same as that described for determination of the drag force from the nomograph.

APPENDIX A-3

Some Designs of Concrete Ballasts

Concrete ballast designs may take on a variety of different sizes, shapes and configurations depending on job-site needs, installation approach and/or availability of production materials. Table A-3-1 below provides some typical designs for concrete ballasts and details some suggested dimensional considerations based on pipe size, density of unreinforced concrete at 144 lb/ft^3 and per cent air entrapment in a typical underwater installation. The reader is advised to consider these dimensions and weights for reference purposes only after a careful analysis of the proposed underwater installation in accordance with the guidelines presented in this chapter.

TABLE A-3-1
Suggested Concrete Weight Dimensions (All dimensions in inches)

Nominal Pipe Size	Mean Outside Diameter (inches)	Spacing of Weights To Offset % Air (feet)			Approx. Weight of Concrete Block (pounds)		Approximate Block Dimensions (inches)						Bolt Dimensions (inches)	
		10%	15%	20%	In Air	In Water	"D"	"X"	"Y"	"T"	"S" (min)	"W"	Dia.	Length
3 IPS	3.50	10	6 ¾	5	12	7	4	9	3 ¾	2 ½	1 ½	2 ½	¾	12
4 IPS	4.50	10	6 ¾	5	20	10	5	11	4 ¾	2 ½	1 ½	3	¾	12
5 IPS	5.56	10	6 ¾	5	30	18	6	12	5 ¼	3 ½	1 ½	3	¾	12
6 IPS	6.63	10	6 ¾	5	35	20	7 1/8	13	5 ¾	3 ½	1 ½	3	¾	12
7 IPS	7.13	10	6 ¾	5	45	26	7 5/8	13 ½	6	4 ¼	1 ½	3	¾	12
8 IPS	8.63	10	6 ¾	5	55	30	9 ¼	15 ¼	6 7/8	4 ¼	1 ½	3	¾	12
10 IPS	10.75	10	6 ¾	5	95	55	11 ¾	19 ¼	8 5/8	4 ½	2	4	¾	12
12 IPS	12.75	10	6 ¾	5	125	75	13 ¼	21 ¼	9 5/8	5	2	4	¾	13
13 IPS	13.38	10	6 ¾	5	175	100	13 7/8	24	11	5 ¼	2	5	¾	13
14 IPS	14.00	15	10	7 ½	225	130	14 ½	24 ½	11 ¼	6 ½	2	5	1	13
16 IPS	16.00	15	10	7 ½	250	145	16 ½	26 ½	12 ¼	6 ½	2	5	1	13
18 IPS	18.00	15	10	7 ½	360	210	18 ½	28 ½	13 ¼	8 ¼	2	5	1	13
20 IPS	20.00	15	10	7 ½	400	235	20 ½	30 ½	14 ¼	8 ¼	2	6	1	13
22 IPS	22.00	15	10	7 ½	535	310	22 ½	34 ½	16 ¼	8 ½	2	6	1	13
24 IPS	24.00	15	13 ½	7 ½	610	360	24 ½	36 ½	17 ¼	8 ¾	2	6	1	13
28 IPS	28.00	20	13 ½	10	900	520	28 ½	40 ¼	19 ¼	11 ¼	2	6	1	13
32 M	31.59	20	13 ½	10	1140	660	32	44	21	12 ¼	2	6	1	13
36 IPS	36.00	20	13 ½	10	1430	830	36 ½	48 ½	23 ¼	13 ½	2	6	1	13
40 M	39.47	20	13 ½	10	1770	1020	40 1/8	52	25	15 ¼	2	6	1	13
42 IPS	42.00	20	13 ½	10	1925	1125	42 ½	54 ½	26 ¼	15	2	6	1	13
48 IPS	47.38	20	13 ½	10	2500	1460	48 ¼	60 ¼	29 1/8	17	2	6	1 1/8	13
55 M	55.30	20	13 ½	10	3390	1980	55 ¾	68	33	18 ¾	2	6 1/8	1 1/8	15
63 M	63.21	20	13 ½	10	4450	2600	63 ¾	78	38	18 ½	2	7 1/8	1 1/8	15

Notes to Table A-3-1

1. Suggested underpad material: 1/8" black or red rubber sheet, 1/4" neoprene sponge padding width to be "T"+ 2" minimum to prevent concrete from contacting pipe surface.
2. Concrete interior surface should be smooth (3000 psi – 28 days).
3. Steele pipe sleeves may be used around the anchor bolts (1" for 3/4" bolt, etc.). Hot dip galvanize bolts, nuts, washers and sleeves.
4. A minimum gap, "S", between mating blocks **must** be maintained to allow for tightening on the pipe.
5. To maintain their structural strength some weights are more than the required minimum.
6. Additional weight may be required for tide or current conditions.
7. Weights calculated for fresh water.
8. All concrete blocks should be suitably reinforced with reinforcing rod to prevent cracking during handling, tightening, and movement of weighted pipe.
9. See Table II for alternative weight design and suggested reinforcement for use with 28" to 48" HDPE pipe.

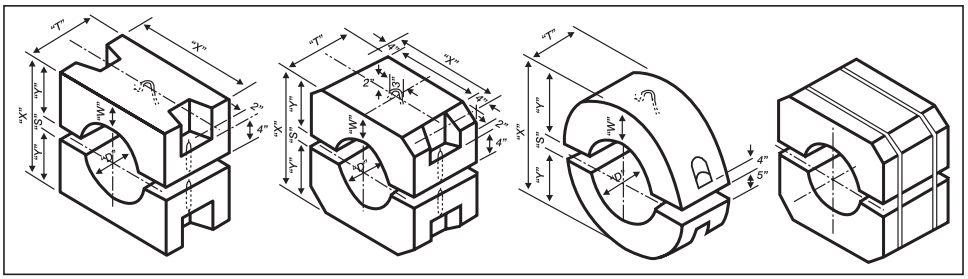

Figure A-3-1 Schematics of Concrete Ballast Designs

TABLE A-3-2

Suggested Dimensions and Reinforcing for Bottom-heavy Concrete Weights (For Extra Stability)
All dimensions in inches

Nominal Pipe Size	Mean Outside Diameter (inches)	Spacing of Weights To Offset % Air (feet)			Approx. Weight of Concrete Block (pounds)		Approximate Block Dimensions (inches)						Bolt Dimensions (inches)	
		10%	15%	20%	In Air	In Water	"D"	"X"	"Y"	"Z"	"R"	"T"	Dia.	Length
28 IPS	28.00	20	13 ½	10	900	520	28 ½	44	19 ½	26 ½	48	7 ½	1	54
32 M	31.59	20	13 ½	10	1140	660	32 1/8	48	21	28	51	8 ½	1	57
36 IPS	36.00	20	13 ½	10	1430	830	36	52	23	30 ½	55 ½	9 3/8	1	61 ½
40 M	39.47	20	13 ½	10	1770	1020	40 1/8	56	25	33	60	10 ¼	1	66
42 IPS	42.00	20	13 ½	10	1925	1125	42 ½	59	26 ½	34 ½	63	10	1 1/8	69
48 M	47.38	20	13 ½	10	2500	1460	48 ¼	64	29	39	70	11 ½	1 1/8	76
55 M	55.30	20	13 ½	10	3390	1980	55 ¾	72	33	43	78	12 ¾	1 1/8	84
63 M	63.21	20	13 ½	10	4450	2600	63 ¾	80	37	47	86	14 ½	1 1/8	92

Notes to Table A-3-2

1. Minimum cover of rebar to be 2 ½".
2. Rebar to be rail steel or equivalent.
3. Anchor bolt material to be ASTM A307.
4. It may be desirable to increase the amount of reinforcing used in the 55" and 63" pipe weights.
5. See recommended bore detail on the following page.

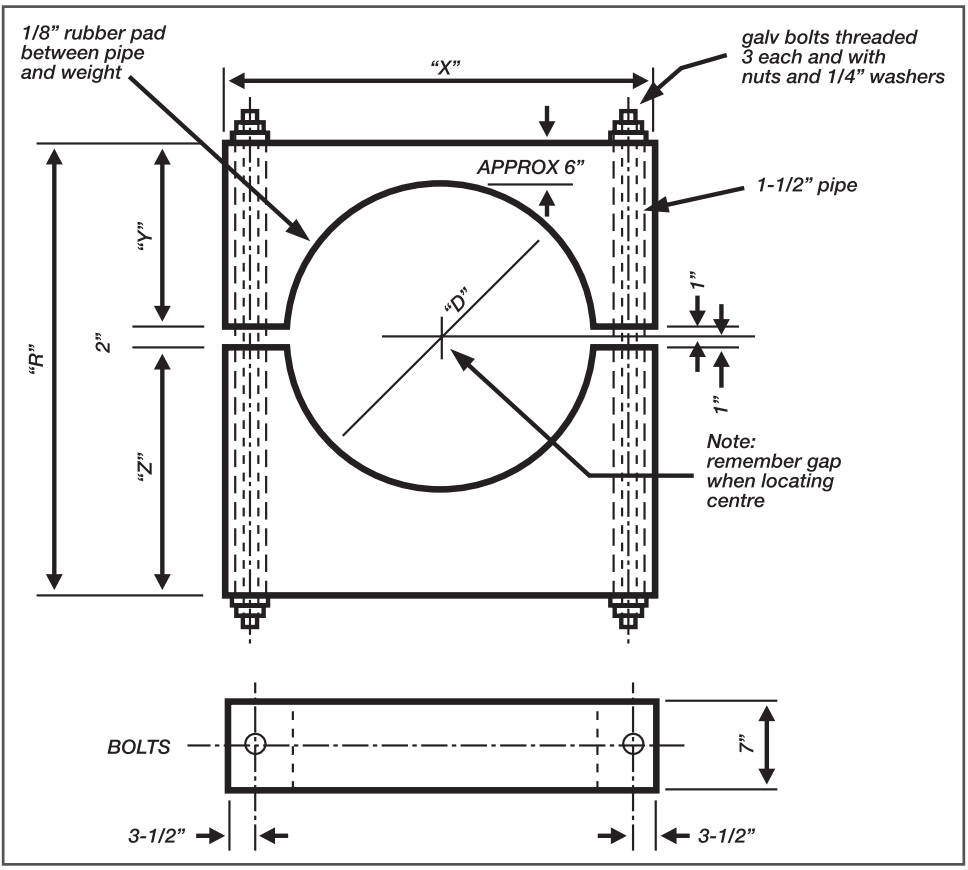

Figure A-3-2 Typical Detail of Concrete Ballast Showing 1-inch Gap Between Ballast Sections

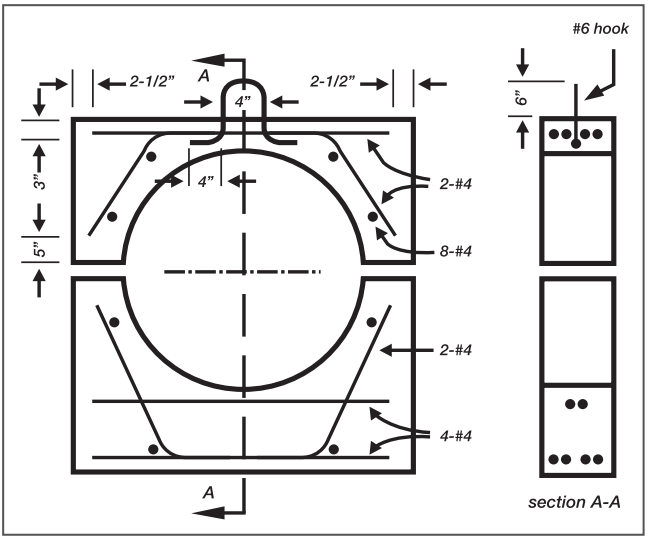

Figure A-3-3 Typical Rebar Detail in Concrete Ballast Design

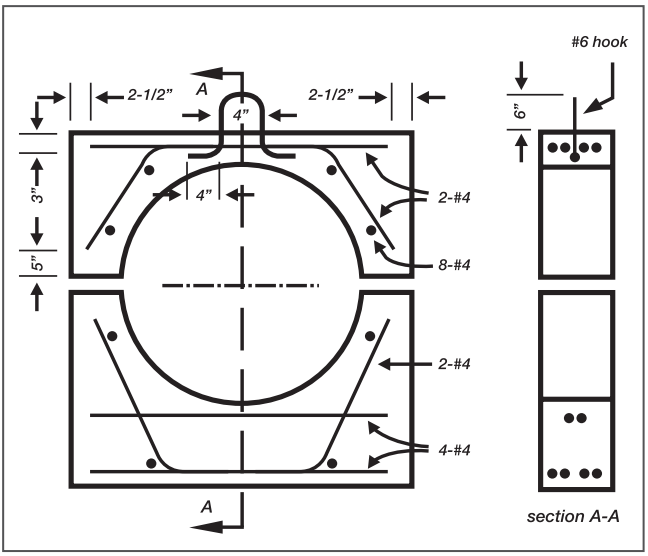

Figure A-3-4 Bore Detail for Concrete Ballast Design