PART 1 --DESCRIPTION

The Contractor shall submit submittal information to the Engineer as stated in the Technical Specification sections. The information must be thorough (drawings, descriptions, samples, manufacturer catalog sheets, etc.) enough for the Engineer to conclusively determine compliance with Specification requirements of Contractor proposed equipment, materials, and methods of work. Contractor shall not proceed with manufacture, fabrication, delivery, or installation of items prior to obtaining the Engineer's favorable review of product submittals.

PART 2 --PROCEDURE

2.1 The Contractor shall submit to the Engineer three copies (which will be retained by the Engineer), plus however many copies that are to be returned to the Contractor, or, alternatively, an electronic pdf file of each submittal item. The Contractor must allow three weeks for approval, and one additional week if a Subconsultant is needed for approval. Submittals of related items shall be delivered as a package for a coordinated review. Related items not included in a single package for coordinated review may be cause for return without review for amendment and resubmittal. The Engineer reserves the right to require submittals in addition to those required in the Specifications.

2.2 The submittals shall be submitted with a transmittal form for each separate item listed for review. The submittal shall be marked with the appropriate title and Section reference for filing. A sequential numbering system shall be assigned to the submittals with a position for marking resubmittals.

2.3 Prior to sending to the Engineer, the Contractor shall review all submittal materials and shall mark their approval and recommendations. All O&M information must be submitted separately from the original submittal and shall be so marked.

2.4 Submittals that are not reviewed and coordinated by the Contractor prior to submittal to the Engineer, including ensuring that all necessary information is included for complete review of a single Section, packaging of items for coordinated review, marking of proposed items and providing recommendations, and crossing out of extraneous items, may be cause for return without review and may delay the review schedule. The Contractor shall not be entitled to a contract time extension due to submittal review delays associated with poorly coordinated submittals.

PART 3 -- REVIEW REQUIREMENTS

3.1 The Contractor is responsible for ensuring compliance with the methods and materials required in the Technical Specifications. Approval of a submittal by the Engineer does not alleviate the responsibility of the Contractor. The Contractor shall maintain responsibility of any errors or omissions, and review by the Owner or the Engineer does not remove any liability or risk of the Contractor. The Contractor can make no claim of failure of the work, material or equipment against any item reviewed.

3.2 Submittals shall include all items and materials within a single Technical Specification section, unless allowed otherwise by the Engineer. Verify that the physical characteristics of items submitted, such as size, configuration, clearances, mounting locations, utility connection

points, and access points, are compatible with the space provided and with interconnecting or interrelated items which have been or are yet to be submitted. When catalog sheets are submitted, the items proposed for use must be clearly marked, and extraneous items shall be crossed out.

3.3 If a submittal represents equipment or methods that are different from those specified, the Contractor is responsible for demonstrating the relevance to the specifications. All variations must be shown in writing for review and must be approved by the Engineer. If the variation creates a change in the Contract Price, a Change Order modification will be generated.

PART 4 -- OPERATION AND MAINTENANCE MANUALS

The Contractor shall furnish three copies of Operation and Maintenance information for the equipment stated in the specifications. The information shall be labeled as an O&M Manual and be bound in a three-ring binder. The sections shall be clearly labeled and tabbed with permanent covers. They shall include information on required maintenance, installation, operations, electrical and hydraulic systems, lubrication and spare or necessary parts.

PART 5 -- CERTIFICATES

When certification of an item or an individual performing the work is required, three copies of the certificates shall be supplied demonstrating that the material and work are being provided in accordance with the Specifications.

PART 6 -- PRODUCT SAMPLES

Where required, three samples shall be supplied to the Engineer for review of proposed material, colors, textures or patterns.

- END OF SECTION -

PART 1 -- GENERAL

1.1 SCOPE: The section covers the furnishing, testing, installation, and removal of temporary water bypass piping for potable domestic water services and fire lines.

1.2 REFERENCES:
American Water Works Association (AWWA)
Federal Specifications (FS)
National Sanitation Foundation (NSF)

1.3 CONTRACTOR SUBMITTALS: In accordance with Section 01300, submit manufacturer's literature for all products specified in this section and certificates of compliance for pipe and fittings. The Contractor shall submit a bypass plan for approval from the Engineer at the preconstruction conference.

PART 2 -- MATERIALS

2.1 PIPE AND FITTINGS: Pipe material and fittings shall be clean; free of rust, dirt, debris and foreign material; and assembled with a non-toxic adhesive. Pipe and fittings shall bear the imprint of the ANSI/NSF 61 approval for potable water. All materials shall be capable of withstanding a minimum of 1½ times the water system maximum operating pressure. All bypass piping shall be sized to provide adequate service volume with a minimum pressure of 40 psi.

A pressure regulating device (PRV) and reduced pressure backflow prevention device shall be required at all fire hydrant connections.

PART 3 -- EXECUTION

3.1 GENERAL: Install piping as shown on the submittal drawing and in accordance with manufacturer's specifications.

3.2 INSTALLATION OF TEMPORARY WATER SERVICE PIPE AND APPURTENANCES: Unless specifically authorized by the Engineer, all temporary water service piping shall be installed as follows:

The location of the bypass piping shall be approved by the Engineer and must be placed within the Right of Way, either in the flowline of the curb, along the back edge of the sidewalk, or as specified. Water meters shall be removed and individually tagged with the corresponding street address and safely stored by the Contractor. Special precautions must be taken when removing meter lids with sensor wiring. Meter pits must be covered. An orange highway cone or Type 1 barricade shall be placed over or next to connections. Tee connections at every meter pit will be required with small diameter pressure rated hose connecting the tee to the residence side of the meter yolk.

Valving on the main bypass line will be required at the terminal end and periodically along the line as approved by the Engineer. All bolted connections shall have the bolt ends facing downwards toward the roadway surface.

A pressure regulating device (PRV) and reduced pressure backflow prevention device shall be required at all fire hydrant connections.

Trenching and cold mix asphalt patching will be required where piping crosses paved surfaces. Crossings at driveways and walks shall require a ramp of pre-formed rubber or tar paper with cold mix asphalt. The ramp system shall be approved by the Engineer.

The Contractor shall be responsible for all bypass operations and maintenance 24 hours a day throughout the contract period until the temporary service provisions are removed. Any and all leaks shall be repaired or replaced immediately by the Contractor at its expense. Any damages to structures, automobiles, service lines, water meter assemblies shall be repaired or replaced at the Contractor's expense. Temporary service lines shall be insulated when applicable to prevent freezing. Should freezing weather make it necessary for the Contractor to discharge water from the bypass pipe into the gutter or storm sewer, to prevent freezing, install a Watts No. 8 atmospheric hose bib vacuum breaker such that the discharge water passes through the breaker and into the curb or inlet. No additional cost will be paid to the Contractor for extra labor that inclement weather may cause.

3.3 UNLOCATED WATER SERVICE LINES: Additional water service taps, not shown on the drawings, may exist that will require service from the bypass system. Immediately upon discovery, the Contractor shall provide temporary service by connection to the bypass piping with minimum interruption of service.

3.4 DISINFECTION OF TEMPORARY PIPING: Piping and appurtenances shall be disinfected as specified in Section 02510.

- END OF SECTION -

PART 1 -- GENERAL

1.1 SCOPE: The work to be performed under this Specification shall include all labor, materials, equipment, and services as are necessary for the excavating and backfilling of all pipeline trenches and utility structures. Any modifications or additions to this Specification are set forth in the "Special Construction Provisions."

The work shall include the excavation of whatever substances are encountered to the depths shown on the Drawings or modified in the field by the Engineer and installation of compacted bedding, backfill, and surface restoration as described herein.

Wherever in this Specification a Standard is quoted or used, such as, but not limited to, ASTM, AWWA and ACI, this shall be interpreted to be the latest revision of that Standard.

1.2 REFERENCES: The Contractor must conform to the amended Rules and Regulations of Construction Standards for Excavations, CFR 29, Part 1926, Subpart P of Title 29 including appendices of the Occupational Safety and Health Administration, Labor, including revisions thereto. The Contractor is solely responsible for excavation safety.

A. American Society for Testing and Materials (ASTM)

B. American National Standards Institute (ANSI)

C. American Water Works Association (AWWA)

1.3 CONTRACTOR SUBMITTALS: Submit in accordance with Specification 01300. Submit the following:

A. Certified laboratory test results demonstrating that imported materials meet the requirements of this Section, including gradation, optimum moisture content, and maximum density. Particle size analysis of soils and aggregates shall be determined in accordance with ASTM D422. Test results shall be dated within 12 months of the date of the submittal.

B. Mix design for Controlled Low Strength Material (CLSM).

1.4 QUALITY ASSURANCE:

A. All soils testing will be done by a testing laboratory of the Owner's choice at the Owner's expense except under the following condition:

In the instance that tests of fill or backfill show non-compliance with the required density, gradation, or other physical properties, the Contractor shall complete the requirements to accomplish compliance. Subsequent testing to demonstrate compliance shall be by a testing laboratory selected by the Owner and shall be at the Contractor's expense.

B. Where soil material is required to be compacted to a percentage of maximum dry density, the maximum density at optimum moisture content will be determined in accordance with ASTM D1557, Modified Proctor. Where granular, cohesionless material is required to be compacted to a percentage of relative density, the calculation of relative

density will be determined in accordance with ASTM D4253 and D4254. Field density tests will be performed in accordance with ASTM D1556, ASTM D2922, or by other means acceptable to the Engineer.

1.5 GENERAL REQUIREMENTS: Except as shown otherwise on the Drawings, all excavation shall be made by open cut. Permission may be granted to tunnel under driveways, crosswalks, curbing, walkways, and utility installations, but such tunnels shall not exceed 10 feet in length.

The length of trench permitted to be open at any one time may be limited when, in the opinion of the Engineer, such limitation is necessary for protection of the work or the convenience of the public.

When excavations are through turf lawns, cultivated fields, pastureland, or areas having natural grass cover, the Contractor shall stockpile separately all stripped topsoil (as specified in the Site Preparation Section), which shall be replaced to at least the same depth on top of the trench backfill. All surfaces that have natural grass cover shall be reseeded by the Contractor as specified elsewhere and in accordance with the referenced erosion control best management practices. All lawns and other grass-covered areas, not excavated, on which excavated material is placed, shall be protected from damage by placing burlap over the grass. Where indicated on the Drawings or required herein, removed turf lawns shall be replaced with sod of the same species.

It is the general intent and requirement that the Contractor leaves the work area in a similar and equal condition as it was preceding the Contract work.

1.6 PROTECTION OF EXISTING FACILITIES:

A. General: Existing power lines, telephone lines, 6-inch and greater diameter trees, shrubbery, fences, water mains, gas mains, sewers, cables, conduits, ditches, embankments, and other structures in the vicinity of the work not authorized to be removed, shall be supported and protected from injury by the Contractor during the construction and until completion of the work affecting them. The Contractor shall be liable for all damages done to such existing facilities and structures, as herein provided and he shall save the Owner from any liability or expense for injuries, damages, or repairs to such facilities.

B. Underground Facilities: The type, size, location, and number of known underground facilities have been shown on the Drawings based on information available to the Engineer at the time of design; however, no guarantee is made as to the true type, size, location, or number of such facilities, or that all facilities are shown. It shall be the sole responsibility of the Contractor to verify the existence and location of all underground utilities along the route of the work. The omission from, or the inclusion of, utility locations on the Drawings is not to be considered as the nonexistence or definite location of existing underground utilities.

The Contractor shall notify the owner or owners of the existing utilities, whether aboveground or underground, 48 hours prior to proceeding with trench excavation whenever such trenching operations are within ten feet of the possible location of any

existing utility. The notification shall also include a request for field staking any such underground facility that may be in the area of influence by the construction.

Should any such utility be damaged in the trenching operations, the Contractor shall immediately notify the owner of such utility and, unless authorized in writing by the owner of utility, the Contractor shall not attempt to make repairs except to prevent further damage to property. Duplicate copies of any written authorization given to the Contractor to make repairs shall be filed with the Engineer and shall be so worded as to save the Owner from any responsibility whatsoever relative to the sufficiency of the repairs.

If a conflict that is not shown on the Drawings develops between an existing utility and the work required by this Contract, the Contractor shall notify the owner of the utility and the Engineer immediately in writing. Such conflict may be considered, by the Engineer, to be a change in the work. The Contractor may request a change in the Contract amount for such change in the work, subject to the General Conditions.

If during construction any underground utility conduit, including sewers, water mains, gas mains and drainage structures, or any aboveground utility facilities are required to be relocated, the Contractor shall notify the utility owner well in advance of approaching the utility so that arrangements can be made with the owner or owners for its relocation without delay to the work.

The cost of relocating both underground and aboveground utilities, exclusive of water and sewer service connections, will be borne by the Owner.

1.7 SUBSURFACE INFORMATION: Except as may be shown on the Drawings or set forth in the "Special Construction Provisions," no additional subsurface exploration has been made along the pipeline alignment as a part of this project.

1.8 EXCAVATION: Excavation shall be categorized as either classified or unclassified.

A. Unclassified excavation shall include the removal and subsequent handling of any and all materials and substances encountered (including rock) in performance of the work, regardless of the type, character, composition, or condition thereof. For unclassified excavation, the cost for all excavation is to be included in the unit price for pipeline installation. Classified excavation shall be as described in the following Paragraph.

B. Classified excavation shall be categorized as either "Earth" or "Rock."

1. Earth Excavation shall include all material not having properties required for classifications as rock excavations; shall include all loose, broken, and/or laminated rock or stones and boulders which can be reasonably broken, plowed, and removed with skillfully operated, power-driven excavating equipment and having comparable capabilities of a normal excavating machine. Unless otherwise stipulated, a "normal excavating machine" shall be assumed to be a Caterpillar 365 or equivalent using a single ripper tooth.

   Soft sandstone or similar material which can be reasonably broken and removed by a backhoe or trencher will not be classified or paid for as "Rock" excavation.

2. Rock Excavation shall include all solid rock masses which cannot be reasonably broken, plowed, and removed with power-driven equipment specified above in “Earth Excavation” and boulders or stones which, because of size or position in the trench, require blasting for removal. Payment for blasted rock excavation shall only be made for volumes within trench limits specified below; except that payment for any one blasting operation, which is successful in the opinion of the Engineer, shall be for not less than one cubic yard.

   The maximum authorized trench width shall not exceed the trench width given in the table in Part 3 herein, and the depth shall be 4 inches beneath the established elevation of the pipe invert.

   For blasting operations, suitable weighted coverings shall be provided to confine all materials lifted by the blasting to within the limits of the trench or other excavation. The Contractor shall comply with all laws, ordinances and applicable safety code requirements and regulations relative to the handling, storage and use of explosives and the protection of life and property and he shall be responsible for all damage thereto caused by his blasting operations.

   As rock excavation is encountered, the Inspector and the Contractor must agree that such material to be excavated is rock. At the end of each day's work, the Inspector, upon request, will calculate and inform the Contractor of the amount of rock excavated for payment purposes. If the Contractor does not agree to the Inspector's quantities, they shall notify the Engineer and Owner within one day's time.

PART 2 PRODUCTS

2.1 GENERAL: All backfill material shall be approved before use. Material from project excavations may be used for backfill. The backfill material shall be free from rubbish, large stones, clods, roots, brush, debris, frozen lumps of earth, or other objectionable material and shall be moisture conditioned (dried or moistened) prior to placement and compaction as specified.

The Contractor is solely responsible for the stability of slopes during construction. Excavation and fill operations shall be coordinated with water control and stabilization measures to prevent unstable conditions.

A. Water shall be clean and free from harmful substances. The amount of water used in compaction shall be sufficient to obtain the percent of compaction required.

B. Topsoil is defined as the existing material nominally within a 6-inch depth beneath the existing ground surface. The Engineer shall verify the suitability of this material as topsoil for use in restoration of the site following construction prior to stockpiling.

2.2 PIPELINE BEDDING AND BACKFILL:

A. Trench Zones: For the purposes of this Specification, the terms “Bedding Zone,” “Pipe Zone” and “Backfill Zone” shall refer to the trench zones as identified following:

1. Bedding Zone. The Bedding Zone shall consist of all material placed below the pipe invert or, when permitted, the native materials graded and prepared for direct placement of the pipe.

2. Pipe Zone. The Pipe Zone shall consist of all material placed above the pipe invert to an elevation 12-inches above the top of the pipe.

3. Backfill Zone. The Backfill Zone shall consist of all material above the Pipe Zone.

B. Materials: All bedding and backfill material shall have the approval of the Engineer and shall be included in the unit price for the pipe unless otherwise specified and indicated in the Proposal. All bedding and backfill material shall be free of frozen material, organic material and debris. All imported materials shall be, and native materials may be, subject to gradation tests and compaction tests prior to approval of the use of that material. Test results shall be certified by a qualified testing laboratory, and submitted to the Engineer for approval and verified as to their accuracy. The cost of these tests shall be borne by the Contractor.

1. Sand Bedding or Sand Backfill Material. This material shall be imported; a clean, well-graded sand conforming to the following limits when tested by means of laboratory sieves:

Well-Graded Sand

Sieve Size	Total Percent Passing by Weight
⅜ inch	100
No. 4	70 - 100
No. 8	36 - 93
No. 16	20 - 80
No. 30	8 - 65
No. 50	2 - 30
No. 100	1 - 10
No. 200	0 – 3

2. Roadbase Bedding Material, Roadbase Backfill, or Roadbase Material. This material shall be imported conforming to Class 6 aggregate base course as specified by the State of Colorado Department of Transportation; and shall meet the following gradation:

Sieve Size	Total Percent Passing by Weight
¾-inch	100
No. 4	30 - 65
No. 8	20 - 55
No. 200	3 - 12

3. Granular Bedding or Granular Backfill Material. This material shall be imported crushed rock or angular surfaced gravel and meet the following gradation (ASTM D448, No. 67):

Sieve Size	Total Percent Passing by Weight
¾-inch	100
⅜-inch	20-55
No. 4	0-10
No. 8	0-5

4. Select Material. Select Material shall not be permitted unless authorized by the Engineer. This material shall consist of suitable material screened from the excavated earth having no rocks or stones greater in size than 2 inches for DIP or RCP and 3/4-inch for all other pipe.

When specified and acceptable Select Material (suitable for placement within 12 inches of the pipe barrel) is not available at any particular location, the Contractor shall screen out rocks and stones larger than permitted or shall provide acceptable screened material from excavations at other locations of the work under this Contract. No extra cost will be paid for moving and handling of Select Material. If sufficient material is not reasonably available, the Contractor shall notify the Engineer. If the Engineer agrees, the Contractor will locate a source of suitable material.

5. Trench Stabilization Material. This material shall be crushed rock, concrete aggregate. When approved by the Engineer, crushed recycled concrete rubble meeting the same gradation may be used.

6. Backfill Material. Backfill Material shall consist of suitable material from the native excavated earth, after clearing, grubbing, and stripping activities have been completed and meeting the requirements of 3.08, F. “Backfill Zone”. Material shall be processed or screened to remove organic matter, deleterious material, and all rock larger than 6 inches in any dimension.

Existing concrete or clay sewer pipe shown to be removed may be used in the backfill material provided it is crushed to meet the requirements herein, and steel reinforcement, if any, is removed and disposed off-site.

7. Imported Backfill Material. Imported material conforming to Class 1 Structural Backfill Material per the 2011 edition of the Colorado Department of Transportation (CDOT) Standard Specifications paragraph 703.08 “Structure Backfill Material”.

8. Controlled Low Strength Material (CLSM) Backfill. This material, also known as flowfill, flash fill, or equivalent shall be placed in the trench where designated on the drawings or as directed by the Engineer. The Contractor may elect to utilize CLSM in lieu of Backfill Material in the Backfill Zone to reduce duration of open trenching in roadways, subject to the approval of the Engineer, or when dictated

by the agency having jurisdiction over the roadway or right-of-way. Mix design shall be submitted to the Engineer for approval.

CLSM shall have a 28-day strength of 60-100 psi, and a maximum slump of 7-10 inches.

C. Special Cutoff Zones: Where designated to prevent flow of water along pipeline trenches use all clay soil (CL per unified classification system). Prepare material to allow good bedding conditions and backfill for pipe.

PART 3 -- EXECUTION

3.1 PREPARATION:

A. Ground Surface Preparation: Prior to excavating, complete all clearing and grubbing and demolition operations as specified herein.

B. Topsoil: In natural areas where excavation will occur, strip all topsoil, or in the absence of topsoil, strip the top surface material and store separately from other excavated materials as specified herein.

C. Concrete Walks, Paved Roadways, Parking Areas, and Road Crossings: Cut existing pavement full depth to a true line before excavation. Cutting of concrete shall occur along the lines of existing joints, unless noted otherwise.

D. The Contractor is to field-verify by excavation the location of all utility crossings, service connections, and connections to existing lines before proceeding with trenching operations.

3.2 TRENCH EXCAVATION:

A. TRENCH WIDTH: The minimum clear trench width measured at the top of the pipe barrel shall be not less than the outside pipe diameter, plus 16-inches.

For all pipe, the maximum clear trench width measured at a point 12-inches above the top of the pipe barrel shall be not greater than the trench width shown on the following table.

MAXIMUM TRENCH WIDTH TABLE

Pipe Diameter (inches)	Maximum Trench (inches)	Pipe Diameter (inches)	Maximum Trench (inches)
4	24	24	48
6	26	27	52
8	28	30	56
10	30	33	60
12	33	36	68
14	35	39	72
15	36	42	75
16	37	48	82
18	40	54	89
20	42	72	110
21	44		

If the above-stated maximum trench widths are exceeded, either through accident or otherwise, and if the Engineer determines that the combined dead and live loads will exceed the design loadings on the pipe, the Contractor shall either cradle the pipe in concrete, or use a pipe of a stronger class, as required by the Engineer. The cost of such remedial measures shall be entirely at the Contractor's expense.

B. TRENCH WALLS: The Contractor may slope or bench the trench side walls. Such sloping or benching shall terminate at a depth not lower than one foot above the top of the pipe barrel, and from that point down, the trench wall shall be vertical and conforming to the specified maximum trench width. The trenching operation, including the spoil bank and sloping of the trench sidewalls shall be confined to the width of the permanent and temporary rights-of-way or easements, if any.

A clear area shall be maintained a sufficient distance back from the top edge of the excavation to avoid overloading which may cause slides or caving of the trench walls. The excavated material shall be kept trimmed in such a manner as to be of as little inconvenience as possible to the public and adjoining property owners. Unless otherwise authorized by the agency having jurisdiction, all public thoroughfares and crossroads shall be kept open to traffic. Bridging (trench plating) shall be used, only when required and authorized by the agency having jurisdiction and the engineer, at street crossings, sidewalks and other points where necessary, to prevent serious interruption of travel and to provide access to fire hydrants and public and private premises.

C. TRENCH DEPTH: The trenches shall be excavated to such depths that the pipeline can be laid at the elevation of the grade lines shown on the Drawings, or at depths or covers specified on the Drawings.

1. Ductile-Iron Pipe and Reinforced Concrete Pipe (ASTM C76 and C361). The trench shall be excavated to the depth required to install the pipe on firm, undisturbed native soil. With the approval of the Engineer, the Contractor may over excavate the trench to a depth as shown on the drawings and the trench bottom brought to the pipe invert with the specified Bedding Zone material.

For areas where large stones or rock excavation are required, so that hand-shaping of the trench is impractical, the trench shall be over excavated to a depth as shown on the drawings and the trench bottom brought to the pipe invert with the specified Bedding Zone material.

2. All Other Pipe Materials. The pipe trench shall be excavated to a depth as shown on the drawings below the bottom of the pipe and backfilled with the specified Bedding Zone material.

D. TRENCH PREPARATION: The trench shall be excavated only so far in advance of pipe laying as permitted by the Engineer, as dictated by public safety, or by the agency having jurisdiction over the public right-of-way or easement. The trench wall shall be so braced that the work may be executed safely and efficiently. All trenches shall be drained so that pipe laying may take place in un-watered conditions. Trench preparation shall also conform to the details shown on the Drawings.

Trenches above a point 12-inches above the top of the pipe shall be of such extra width, when required, as will permit the convenient placing of timber supports, sheeting and bracing, and the handling of special units as necessary.

Bell holes in the trench bottom shall be provided at each joint to permit the jointing to be made properly and to prevent the pipe from bearing on the bells.

After excavation, the trench bottom shall be uniformly graded and hand-shaped so that the pipe barrel (exclusive of the joint) will have uniform and continuous bearing on firm, undisturbed trench bottom (when permitted), or thoroughly compacted granular bedding or sand material, throughout the length of the pipe. The trench grade shall permit the pipe spigot to be accurately centered in the preceding laid pipe joint, without lifting the pipe above the grade and without exceeding the permissible joint deflection. If it is necessary to raise the pipe subgrade, approved, compacted granular bedding material shall be used at the Contractor's cost.

If unstable foundation is encountered, the Contractor shall notify the Engineer immediately, prior to excavating the unstable material and backfill the over excavation with 12-inch uniformly-graded, specified Trench Stabilization Material. If larger material is needed, it must be approved by the Engineer prior to placement. Payment for over excavation for unstable bedding and supplying and installing of Trench Stabilization Material that has been authorized by the Engineer beyond the bid quantity will be negotiated by Change Order.

PART 4 -- SHORING:

A. As needed, all trench sidewalls shall be properly sheeted and braced to meet Federal, State and local laws in regard to safe working conditions. The Contractor shall be solely responsible for providing adequate excavation safety. The shoring shall be arranged so as not to place any stress on portions of the completed work until the general construction thereof has proceeded far enough to provide ample strength. Any damage to pipes or structures resulting from settlements, heaving, water or earth pressures, slides, caving, or other causes, due to lack of shoring, sheeting, or bracing, or due to

failure of shoring, or due to improper shoring, or due to any other negligence on the part of the Contractor, shall be repaired by the Contractor at their own expense.

B. Shoring shall be removed as the work progresses, unless left in place by written order of the Engineer. The Contractor will be paid for shoring so ordered left in place on the basis of invoiced material cost only.

C. If the Engineer is of the opinion that at any point the trench walls are not properly supported to protect the work, the Engineer may order the placement of additional supports by, and at the expense of, the Contractor. Compliance with such order shall not relieve or release the Contractor from their sole responsibility for safety and the protection of the work.

PART 5 -- OVEREXCAVATION OF UNSUITABLE MATERIAL: In areas where unsuitable or unstable material is encountered, the Contractor shall over-excavate and remove the unsuitable material and backfill and compact with material approved by the Engineer. Overexcavation and replacement of unsuitable material will be done only upon authorization by the Engineer. Payment for authorized work will be negotiated by Change Order.

PART 6 -- REMOVAL OF EXISTING WATER OR SEWER LINES: The Contractor shall remove and dispose of any abandoned water or sewer pipelines encountered that are within 18-inches of the new or replacement pipeline.

PART 7 -- WATER CONTROL AND DEWATERING: For all excavations, the Contractor shall provide suitable equipment to divert and/or remove surface, rain, and groundwater regardless of quantity or rate of flow. The excavation shall be continuously maintained in an un-watered condition so that pipeline construction and backfill operations can be executed at all times under dewatered conditions.

Water shall be disposed of in a suitable manner without damage to adjacent property and without being a menace to public health and convenience. No water shall be drained into the previously constructed Work or Work in progress without prior consent of the Engineer.

Dewatering shall be accomplished by well points, sumping, or any other suitable method that ensures an unwatered trench to a minimum of two feet below the excavation bottom, so that the Contractor's operations will not disturb the trench bottom foundation. Any dewatering method shall be subject to the approval of the engineer. Dewatering by overexcavation and installation of crushed rock shall not be paid as rock used for trench stabilization.

PART 8 -- STORAGE OF EXCAVATED MATERIALS:

A. Generally excavated material will be stockpiled near the immediate construction area so as not to interfere with other work.

B. In natural areas, place excavated materials close to the excavation and in as confined a configuration as possible. Where adjacent slopes are too steep to stockpile, transport materials to special stockpile locations in nearby areas. All transportation to and from stockpiles (including loading and unloading) shall be included in the work.

PART 9 -- TRENCH BACKFILL:

A. GENERAL: Use mechanical compaction equipment appropriate for the use and material to achieve the specified level of compaction. Compaction by means of flooding or jetting with water shall not be acceptable.

When required by the Engineer the Contractor shall excavate backfilled trenches for purposes to perform compaction tests at locations and depths required by the Engineer. The Contractor shall be responsible to reinstall and compact the test excavations at no additional cost to the Owner.

B. COMPACTION STANDARD: Unless accurate results cannot be obtained, the compaction requirements shall conform to maximum dry density according to ASTM D1557, Moisture-Density Relations of Soils (Modified Proctor). When the ASTM D1557 test is not applicable for a given material, the percentage compaction requirements shall conform to ASTM D4253 Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

C. MOISTURE CONDITIONING: All imported and native earthwork materials shall be properly moisture conditioned (wetted or dried as necessary) to obtain a moisture content within three percent (3%) of optimum prior to placement and compaction. Employ such means as may be necessary to secure a uniform moisture content throughout the material of each lift being compacted.

D. BEDDING ZONE: Bedding material shall be placed to the required elevation of the bottom of the pipe barrel. Bedding Zone installation shall comply with the following:
   a. Material: Granular Bedding.
   b. Compaction: Tamping equipment shall be used to thoroughly tamp the bedding material to a minimum of 95 percent of maximum dry density.

E. PIPE ZONE: After the Bedding Zone has been placed and has been approved and, after the pipe has been installed and approved, the Pipe Zone material shall be installed to an elevation 6-inches above the top of the pipe. Pipe Zone installation shall comply with the following:
   a. Material: Granular Backfill Material.
   b. Compaction: Minimum of 95 percent of maximum dry density utilizing T-bars or mechanical tamping equipment.
   c. Installation Requirements: Place and compact in distinct, separate lifts not to exceed 6-inches of loose depth; except that the first loose lift shall not be higher than the pipe centerline (springline).

F. BACKFILL ZONE: All backfill above the Pipe Zone shall be carefully placed and compacted. The Backfill Zone installation shall comply with the following:
   a. Material: Backfill Material, or Imported Backfill Material when authorized by the Engineer.
   b. Compaction:
      i. Outside of roadway limits: Minimum of 90 percent of maximum dry density.
      ii. Within roadway limits: Minimum of 95 percent of maximum dry density.
   c. Installation Requirements:

i. Compaction shall be by mechanical tamping in 8-inch maximum loose lifts using mechanical or hand tampers, weighing not less than 20 pounds, or vibratory rollers. All other means must be approved in writing by the Engineer. The Contractor may request approval of alternate means of compaction. Such request must be submitted to the Engineer in writing. Approval of the compaction method will be made by the Engineer only in writing. Use of specified or approved compaction methods does not relieve the Contractor from providing a complete project meeting the intent and requirements of this Specification.

ii. Selectively screen and place Backfill Material such that rock larger than 6 inches in any dimension is omitted from the top 12 inches of the Backfill Zone, and rock larger than 8 inches in any dimension is omitted from the Backfill Zone within 4 feet above the top of pipe.

iii. In turf or natural grass areas, the top 6 inches of the Backfill Zone shall consist of stockpiled Topsoil or organically amended soil, compacted to no greater than 85% of maximum dry density. Roughen the surface of the underlying compacted trench backfill material to afford good adhesion between the two soil types.

G. WARNING TAPE AND TRACER WIRE: Install warning tape and/or tracer wire in coordination with the trench backfilling operation as specified in the Specification Sections for pipeline materials and as shown on the Drawings.

PART 10 -- SURFACE RESTORATION:

A. GENERAL: Unless indicated otherwise in the Proposal, the cost of surface restoration shall be included in the cost of the pipeline installation.

B. IMPROVED ROADWAYS: Unless noted otherwise or required by the agency having jurisdiction, all paving, curb and gutter, sidewalks, and other street improvements removed or damaged during construction shall be replaced with the same type and dimensions of items removed or damaged to the same line and grade, and shall be equal to, and consistent with, the undisturbed portions of the improvements existing prior to the trench excavation.

a. Concrete curb, gutter, and sidewalk. All concrete used in the restoration work shall conform to the requirements of the Street or Highway Department having jurisdiction. Comply with the standard details shown on the drawings for such items, or if not shown, with the applicable local standards in effect. Pedestrian sidewalk ramps shall comply with the latest ADA standards. Subgrade shall be thoroughly compacted as specified. Provide compacted Roadbase Material beneath concrete work to the thicknesses shown on the Drawings or to match existing thicknesses.

b. Asphalt Pavement: After the Backfill Zone has been approved by the Engineer, and the Highway or Street Department having jurisdiction has approved the pavement subgrade, place and compact a layer of Roadbase Material. The thickness of the material shall be as shown on the Drawings, or match existing – whichever is greater. Compact the material to a minimum of 95% maximum dry density, or greater if required by the agency having jurisdiction.

Asphalt shall be hot mix in accordance with the standards of the Highway Department having jurisdiction, or as specified elsewhere in these Contract Documents if more stringent. The thickness of the asphalt shall be as shown on the Drawings, or match the existing paving thickness, whichever is greater. In no case shall the asphalt be less than 3 inches in thickness.

Preparation for paving shall include sawcutting the pavement with a vertical face 12 inches beyond the trench wall or limit of damaged pavement, cleaning, prime and tack coats. The depth of the saw cut shall be equal to the full depth of existing pavement. After placing the material, the pavement shall be compacted with a smooth roller. All methods shall meet the requirements of the Highway Department having jurisdiction. The final paved surface shall be uniform so that if tested with a 10-foot straight edge, the variation shall not exceed one-quarter inch. Areas not complying with these tolerances shall be reworked to obtain conformity at no additional cost to the Owner.

Regardless of the amount of pavement damaged by construction equipment or activities or removed during installation of the pipelines, the maximum width of pavement replacement that will be paid for will be up to 36 inches on either side of the pipe centerline and a maximum total width of 72 inches if pavement is excavated on both sides of the pipe centerline and shall include all base course, cleaning, prime coat, tack coats, and asphalt pavement. The cost of pavement removal and replacement outside these limits shall be included in the bid cost of the pipe. Comply also with Section 02740.

C. ROAD GRAVEL SURFACING: Gravel surfacing that is removed, disturbed, and/or contaminated during trench excavation or construction activities shall be replaced. After the backfill has been approved by the Engineer, the gravel shall be placed to a 6-inch minimum thickness. The gravel shall be compacted by a vibratory roller to the elevation of the undisturbed surface. The gravel shall conform to the requirements of the Highway or Street Department having jurisdiction. If no requirements apply, the material shall be Roadbase Material.

D. TURF: The top 6-inches of the Backfill Zone shall consist of stockpiled Topsoil or organically amended soil, compacted to no greater than 85% of maximum dry density. Sod, defined as densely grassed landscaping turf, which is removed shall be replaced with new sod of the same species and quality, or the sod removed may be put back if it has been properly stored and remains in a healthy condition.

E. NATURAL AREAS: The top 6-inches of the Backfill Zone shall consist of stockpiled Topsoil or organically amended soil, compacted to no greater than 85% of maximum dry density. Seed and provide prescribed revegetation and erosion and sedimentation control measures as specified elsewhere or on the Drawings, and in accordance with the referenced erosion and sediment control best management practices.

F. OTHER ITEMS: The Engineer will clarify restoration of other minor items as construction proceeds. Such items must be restored to equal or exceed existing conditions.

PART 11 -- CLEANUP: Prior to final inspection and acceptance, remove all rubbish and excess materials and leave area in a neat, satisfactory condition.

PART 12 -- MAINTENANCE OF BACKFILL: All backfill shall be maintained in a satisfactory condition and all places showing signs of settlement shall be filled and maintained during the life of the Contract and for a period of one year following the date of final acceptance of all work performed under the Contract. When the Contractor discovers or is notified by the Engineer or the Owner that any backfill is not in compliance with the provision of this Contract, the Contractor shall correct such conditions at once at no additional cost to the Owner. Any utilities and road surfacing damaged by such settlement shall be repaired by the Contractor to the satisfaction of the Owner and Engineer or agency having jurisdiction. In addition, the Contractor shall be responsible for the cost to the Owner of all claims for damages filed with the Court, actions brought against the said Owner for, and on account of, such damage.

- END OF SECTION -

PART 1 -- GENERAL

1.1 DESCRIPTION: The work of this section consists of temporary measures for the control of erosion, sedimentation, and other pollutants during construction. Work includes installation of such measures in accordance with the Drawings and any permits for the project, maintenance during the contract period to assure proper function, and removal of temporary measures in coordination with installation of permanent erosion control measures.

The Contractor shall provide and maintain adequate erosion control measures during all phases of construction to protect surface water run-off from transporting eroded materials. The erosion control measures shall be inspected during and after each run-off event, with repairs being made and excess sediment removed as needed. The Contractor is responsible for preventing sediment from traveling off-site or to nearby water sources.

The Contractor shall be responsible for developing the necessary sedimentation and erosion control plans and securing associated permits necessary to execute the work from the agencies having jurisdiction. Provide all needed coordination and payment of fees associated therewith.

1.2 SUBMITTALS: Samples of all materials specified in this Section and submittals demonstrating these materials meet the Specification requirements shall be submitted in accordance with Section 01300.

1.3 REFERENCE STANDARDS: Erosion control details and practices may be obtained from the Urban Drainage and Flood Control District "Urban Storm Drainage Criteria Manual Volume 3 - Best Management Practices", or the "Erosion Control Manual" by the Colorado Department of Transportation. In addition, the Contractor may submit details, sketches, and descriptions of other soil erosion and sediment control measures to utilize during construction (or modifications to the specified practices) for approval by the Engineer.

PART 2 -- PRODUCTS

2.1 CHANNEL SLOPES AND OTHER DISTURBED AREAS: Materials for use as temporary measures include straw bales, loose mulch, mulch blankets, silt fence, sod buffer strips, and other stabilization materials.

2.2 ACTIVE FLOWING STREAM OR DIVERSION: Material for use as temporary measures to stabilize the invert or toe of slope zone of a live stream or diversion channel include pipe, concrete rubble, riprap, plastic sheeting, synthetic erosion control matting, or other functional material that is not hazardous to water quality.

2.3 STORM SEWER OUTFALLS/POINT DISCHARGES: Materials for temporary erosion control on slopes downstream of storm sewer or swale outfalls may be pipe, concrete rubble, riprap, cast-in-place concrete, plastic sheeting, synthetic erosion control matting, or other functional material that is not hazardous to water quality.

PART 3 -- EXECUTION

3.1 GENERAL: Procedures for installation, maintenance, and removal of temporary erosion control measures shall generally conform to the guidelines contained in the criteria manual referenced in Part 1 herein. The specific practices and measures to be implemented depend on the Contractor's construction procedures, sequencing, and general approach to the project.

3.2 CONSTRUCTION IN WATERWAYS: To the extent possible, movement of construction equipment within the flowing portion of channels or waterways shall be minimized. Frequent fording of the stream shall be avoided. Isolate or divert stream flows so construction equipment, materials, and earthwork are not exposed or vulnerable to flow.

3.3 TEMPORARY CONTROLS DURING SITE WORK:

A. All dewatering flows that carry sediment or other deleterious material shall not be directly introduced to the stream. Such flows shall be routed to a sediment basin(s) or trap(s) for treatment prior to discharge to the stream. The intent is to trap material disturbed by construction activities and prevent the discharge of this material into the stream. Sediment basins or traps shall be monitored and maintained no less than weekly (including removal of sediment and/or repair of basin dike or filter material) or whenever the basin fills with sediment to 50 percent of capacity.

B. Properties and roadways adjacent to the Site shall be protected from sediment deposition. This may be accomplished by leaving a sod buffer strip around the lower perimeter of the land disturbance, by installing perimeter controls such as sediment barriers, filters, or dikes, or by a combination of such measures. Construction ingress and egress routes shall be stabilized by gravel or other means to prevent tracking sediment, mud, or debris onto adjacent thoroughfares. Promptly remove soil, sediment, or debris from paved roadways and keep them clean throughout the construction period.

C. Sediment basins and traps, perimeter dikes, sediment barriers (such as straw bale barriers or silt fencing), and other measures intended to trap sediment on-site must be constructed as a first step in grading and be made functional before upslope land disturbance takes place.

D. Diversion channels must be stabilized against erosion by use of riprap or other accepted measures.

E. Roughened soil surfaces are preferred to smooth surfaces on slopes during initial grading operations. Diversion dikes or ditches shall be constructed at the top of long or steep slopes which have significant drainage areas above the slope. Diversions or terraces may also be used to reduce slope length.

F. Concentrated storm water shall not be allowed to flow down cut or fill slopes unless contained within a stabilized channel, flume, or slope drain structure.

G. Wherever a slope face crosses a water seepage plane which endangers the stability of the slope, adequate drainage or other protection shall be provided.

H. All storm drain inlets within or near the Site that are operable during construction shall be protected with filter fabric or a similar approach to remove sediment from stormwater runoff prior to entering the storm drain system.

3.4 DUST ABATEMENT: During the performance of the work required by these Specifications or of any operation appurtenant thereto, the Contractor shall furnish all the labor, equipment, materials, and means required and shall carry out proper and efficient measures whenever and as often as necessary to reduce the dust nuisance and to prevent dust which has originated from its operations from damaging dwellings or causing a nuisance to persons. The Contractor shall be liable for any damage resulting from dust originating from its operations under these Specifications. The cost of sprinkling or of other methods for dust control shall be included in the cost for erosion and sediment control.

3.5 DISPOSITION OF TEMPORARY MEASURES: All temporary erosion and sediment control measures shall be removed and disposed of as permanent measures are being installed. Both operations shall be coordinated to prevent erosion or other damage to the channel or finished grading. Trapped sediment or other disturbed soil areas shall be permanently stabilized to prevent further erosion and sedimentation.

- END OF SECTION -

PART 1 -- GENERAL

1.1 SCOPE: The work of this section includes providing and installing buried ductile iron, PVC, and fittings for water service. All materials shall be new and the best available. All material used shall be manufactured and supplied according to the latest revised standards of the American Water Works Association, the American National Standards Institute, and the American Society for Testing and Materials, or as mentioned hereinafter. Miscellaneous valves and fittings shall be as called out on the Drawings.

1.2 REFERENCES:

A. American Society for Testing and Materials (ASTM)

B. American National Standards Institute (ANSI)

C. American Water Works Association (AWWA)

D. Federal Specifications (FS)

1.3 CONTRACTOR SUBMITTALS: In accordance with Section 01300, submit:

A. Certificates of compliance

B. Manufacturer's installation instructions and recommendations

C. Manufacturer's literature and product data sufficient to demonstrate compliance with the specified requirements.

D. Test results.

1.4 PRODUCT HANDLING:

A. Pipe, fittings, valves, hydrants, and all other accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage to them. Under no circumstances shall any materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground. Skidding which damages protective coatings will not be permitted.

In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench to prevent moving more than once.

All pipe and fittings shall be so handled that the coating and lining will not be damaged. If, however, any part of the coating or lining is damaged, the repair shall be by the Contractor at its expense in a manner satisfactory to the Engineer. Any area damage beyond repair must be cut off and discarded.

B. Do not store materials directly on the ground. PVC pipe should be covered to prevent exposure to direct sunlight.

PART 2 -- PRODUCTS

2.1 DUCTILE-IRON PIPE, FITTINGS, AND APPURTENANCES: All ductile iron pipe, fittings, and appurtenances shall conform to the latest edition of the Denver Water Engineering Standards. Unless revised on the Drawings or in the Special Construction Provisions, the pipe shall be ductile-iron pipe, conforming to ANSI A21.51/AWWA C151, Class 52 thickness. The interior of each length of pipe shall have a cement-mortar lining, conforming to the requirements set forth in ANSI A21.4, of standard thickness. The exterior of the pipe shall be coated with standard bituminous coating approximately one mil thick.

Unless otherwise specified the pipe joint shall be the “push-on” type, made in accordance with ANSI A21.11, and the gaskets shall be standard for buried water service and as provided by the pipe manufacturer.

The fittings shall be ductile-iron conforming to the requirements set forth in ANSI A21.10/AWWA C110 or ANSI 21.53/AWWA C153. Ductile-iron fittings 12-inch size and smaller shall have a minimum pressure class of 350 psi. The interior of the fittings shall be cement-mortar lined, as is required for the pipe with a 1 mil bituminous exterior coating. The fittings shall have mechanical joints in accordance with ANSI A21.11. The gaskets for the joints shall be suitable for potable water service.

A. Conductivity Connections: When pipeline conductivity is required, the continuity across joints shall be provided by factory installed copper straps for in-place bolting or as follows:

   1. Push-on Joints: Provide Cadweld CAM-109 welder and cartridge CA15. Connection wire, copper equivalent to No. 4 solid wire.

B. Polyethylene Encasement: When required, the ductile-iron pipeline and fittings shall be encased in polyethylene film in accordance with the following requirements of ANSI A21.5/AWWA C105.

   1. Polyethylene: The polyethylene film shall be manufactured of virgin polyethylene material conforming to the requirements of ASTM D-1248. The raw materials shall be Type 1, Class A (natural) or C (Black), Grade E-1 with flow rate of 0.4 maximum and dielectric strength of 10^{15} ohm-cm^3 minimum.

   2. Polyethylene Film: The finished polyethylene film shall have a minimum nominal thickness of 0.008-inch (8 mil), and the minus tolerance on thickness shall not exceed 10 percent of the nominal thickness. The film shall have a minimum tensile strength of 1200 psi with an elongation of 300 percent minimum. The dielectric strength shall be 800 volts/mil thickness minimum.

   3. Tube Size or Sheet Width: The tube size of sheet width for each pipe diameter shall be as listed in the following table:

Nominal Pipe Diameter (In.)	Minimum Width (In.) Flat Tube	Sheet
4	16	32
6	20	40
8	24	48
10	27	54
12	30	60

C. Thrust Restraint: Where designated on the Drawings or where existing conditions do not permit the use of concrete thrust blocks, fitting restraints shall be made with tie rods and pipe clamps or special fitting bolts. Tie rod restraint systems shall have a minimum of 2 bolts or rods per joint or clamp. Minimum tie bolt sizes are as follows:

Pipe Size	Bolt Diameter
4" - 8"	5/8”
10 – 14”	3/4"

The tie bolts shall be fabricated from “Cor-Ten” steel or equal according to the requirements of ASTM A242 with a minimum yield stress of 46,000 psi. Retainer clamps shall be equal to “socket clamp,” Figure 595, as manufactured by ITT-Grinnell.

D. Mechanical Joint Retainer Glands: Fitting and joint restraints shall be made with the appropriate retainer gland for the distances as shown on the drawing details. Provide glands manufactured by a Denver Water approved manufacturer. All special tools recommended by the manufacturer shall be used during installation and shall be supplied to the Owner.

E. Restrained Joint Pipe: Restrained joint pipe shall be ductile iron manufactured in accordance with the requirements of ANSI A21.51/AWWA C151. Push-on joints for such pipe shall be in accordance with ANSI A21.11/AWWA C111. Pipe shall be U.S. Pipe TR FLEX or equal. Unless otherwise shown on the Drawings the pipe shall be Class 52 thickness.

Restrained joint fittings shall be ductile iron in accordance with applicable requirements of ANSI 21.10/AWWA C110 with the exception of the manufacturer's proprietary design dimensions. Push-on joints for such fittings shall be as specified above for the pipe. Fittings shall be provided by the pipe manufacturer.

Cement mortar lining and bituminous outside coatings for pipe and fittings shall be as specified above for ductile iron pipe.

Restrained push-on joint pipe and fittings shall be capable of being deflected after assembly. Any special assembly tools recommended by the manufacturer will be supplied to the Owner.

2.2 POLYVINYL CHLORIDE PIPE:

A. **C900 & C905 PVC:** The pipe shall be similar and equal to Class 305 psi, and shall conform to AWWA C900, “Polyvinyl Chloride (PVC) Pressure Pipe, 4-inch through 12-inch, for Water,” and AWWA unless otherwise designated on the Drawings or Special

Construction Provisions. All Class 305 psi pipe shall meet the dimension requirements of DR14 and shall have an equivalent cast-iron pipe outside diameter. For pipe sizes 14 inch through 30-inch, the pipe shall conform to AWWA C-905, "Polyvinyl Chloride Pipe (PVC) Water Transmission Pipe", Class 235 psi, DR 18.

Pipe shall be made from clean, virgin, NSF Approved Class 12454-A or 12454-B PVC conforming to requirements of ASTM D1784.

Provisions must be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. Pipe shall be supplied in laying lengths of 20 feet. All pipe shall be assembled with a non-toxic lubricant. Each length of pipe shall have marked on the exterior the following:

Nominal size and OD base
Material Code Designation
Dimension Ratio number "DR 14"
AWWA Pressure Class "PC 305 psi"
AWWA Designation, "AWWA C900"
Name or Trademark of Manufacturer
National Sanitation Foundation Seal for Potable Water

The fittings shall be ductile iron as specified above.

2.3 STEEL PIPE: The pipe shall be steel pipe, conforming to AWWA C200-86. The wall thickness shall be manufactured to meet ASTM A53 Grade B with a minimum ultimate tensile strength of 60,000 psi and a minimum yield strength of 35,000 psi.

The interior and exterior of the pipe shall have a epoxy paint lining of 12 mils minimum dry film thickness, meeting the requirements of AWWA C210. All bolts, nuts, and washers shall be type 304 stainless steel.

The pipe shall be provided with beveled by square joints.

2.4 CARRIER PIPE SKIDS: Joint Restraint Casing Spacers (carrier pipe skids) shall be installed at each pipe joint with the spigot side of the Restraint Joint Casing Spacer positioned at the "home line" and the bell side at the edge of the bell, per manufacturer's recommendations. The spacers shall provide sufficient restraint to prevent "over-belling" of the joint. The Contractor shall TV the carrier pipe after installation to verify that the spigot has not been over inserted. A minimum of two additional spacers shall be used on 13/14 foot pipe lengths and three additional spacers on 20 foot pipe lengths. The carrier pipe shall be centered and supported in the casing pipe at maximum six foot intervals with pipe skids. The studs, nuts and washers shall be made from T-316 stainless steel. The runners shall be polymer, and have a low coefficient of friction. The spacers shall be stainless steel, as manufactured by Cascade Waterworks Manufacturing Co., CCS-JR and CCS-ER, or approved equal.

2.5 GATE VALVES AND BOXES: Where designated on the drawings, gate valves for buried pipelines two inches and larger shall be iron-body, resilient seated conforming to AWWA C509 for buried service, open right, non-rising stem, 2-inch operating nut, for a working pressure of 150 psi. All head bolts, nuts and washers shall be 316 stainless steel. The direction of closure for the valves shall be determined by the Owner. The joints for valves connected to the ductile-iron or PVC pipe shall be mechanical joints in accordance with ANSI A21.11. All gaskets shall be for standard water service.

Gate valves may be approved ductile or cast iron body. Tapping valves shall be standard tapping valve similar and equal to Mueller 2360 Series.

Gate valves shall be similar and equal to Mueller Series A-2360 Resilient Wedge Gate Valve or Clow.

The valve box shall be installed over each buried valve. The valve boxes shall be of cast iron, complete with cover, having the word "WATER" cast on the top. Boxes shall have 5¼-inch shaft, with a minimum thickness of 1/4-inch. Valve boxes shall be three-piece adjustable screw type, similar and equal to Tyler screw-type Series 6860 with No. 160 oval base. Two operating keys or wrenches shall be provided for this project.

Valves buried deeper than 7 feet of cover shall include an extension key "pinned" to the valve nut with a 1/4-inch stainless steel bolt and include centering guide.

2.6 FIRE HYDRANTS: The fire hydrants shall be equal to the Mueller Centurion Model A-423, factory painted red, with traffic flange having bronze fittings, bronze to bronze seating with O-rings, and other optional materials of bronze.

Valve: 5¼-inch
Inlet: 6-inch with mechanical joint
Trench Depth: varies
Operating Nut: 1 1/2" Pentagon or as required by Fire Department
Open: CW
Nozzles: 2 – 2½-inch, 1 –4½ inch pumper nozzle
Threads: National Standard
Working Pressure: 150 psi

All nozzle caps shall have nut identical to operating nut. Hydrant shall be provided with indicating arrow for opening direction.

One operating wrench, one valve seat wrench and one set of tools required for repair of hydrant shall be provide.

2.7 COUPLINGS: The pipe couplings shown on the Drawings to be used when connecting new pipes or pipes into existing buried pipelines with varying outside diameters shall be similar and equal to "Smith-Blair" 441 cast-iron transition coupling for sizes up to 16 inches. Couplings shall have an interior coating of an epoxy suitable for use with potable water. Exterior coating shall be equivalent to the attached new pipeline.

Couplings for use with new pipe of the same outside diameter shall be "Smith-Blair" 441 cast iron. Coatings shall be the same as the transition couplings listed above.

Coupling bolts shall be high strength, low alloy steel meeting the requirements of ASTM A325, Type 3.

2.8 AIR RELEASE/VACUUM VALVES: If required by the Drawings, the Contractor shall install combination air release/vacuum valves. The valves shall be contained within a precast concrete manhole section as detailed. Valves shall be "APCO" Series 140C, Heavy-Duty Model

No. 143C for 1-inch size, No. 145C for 2-inch size, No. 147C for 3-inch size, and No. 149C for 4-inch size, combination air release valves as manufactured by Valve & Primer Corporation.

2.9 WATER SERVICES: Materials for water service connections shall be new and the best available. In the absence of detailed information, the requirements of AWWA C800 shall be followed.

A. Corporation Stops: All corporation stops for copper pipe shall have threaded inlet, coupling outlet, and working pressure of 300 psi. Corpoartion stops shall be B-25008N Mueller 300 Ball Corporation Valve or FB1000-x-G-NL as manufactured by Ford Meter Box Company.

B. Copper Pipe: The copper pipe for all service connections shall conform to the requirements set forth in ASTM B-88, or its latest revision, and shall be Type K, soft annealed.

C. Curb Valves: All curb valves for 3/4-inch to 2-inch copper pipe shall have coupling connections and a working pressure of 300 psi. Curb valves shall be B-25209N as manufactured by Mueller or B44-xxx-G-NL as manufactured by Ford Meter Box Company.

D. Couplings: Couplings for reconnecting copper service lines shall be C22, Flared couplings and manufactured by the Ford Meter Box Company.

E. Service Saddles: For all PVC pipe and taps greater than 1-inch in diameter on DIP, each corporation stop shall be inserted into a double-strap bronze service saddle; saddles shall be Mueller Series BR2B, Ford Meter Box Company Series 202B, or A.Y. McDonald model number 3825. For all PVC pipe and taps greater than 1-inch in diameter on PVC pipe, each corporation stop shall be inserted into a bronze single-strap service saddle; saddles shall be Mueller H-13000 or S-13000 Series, S90-xxx-NL as manufactured by Ford Meter Box Company, or A.Y. McDonald model number 3805.

2.10 INSULATION: Insulation where shown on drawings shall be Type SM rigid blue closed Type HI-40 as manufactured by the DOW Chemical Corporation or approved equal. Type HI-40 shall be used beneath foundations, all traveled way-in roads and streets, highway shoulders and within 15 feet of pavement unless otherwise specified on the drawings. The galvanized steel jacket may be field applied.

2.11 TAPPING SLEEVE: Tapping sleeves for pipe sizes 12” and smaller shall be ductile iron; for pipe sizes greater than 12”, the sleeves shall be fabricated steel with epoxy coating and stainless steel hardware– per Denver Water Specifications,.

2.12 UNDERGROUND WARNING TAPE: Install 12 to 18 inches below surface grade, 6-inch wide detectable aluminum foil plastic-backed tape indicating buried water line installed below. Tape shall be blue in color and manufactured by Thortec or equal.

2.13 METALLIC TRACER TAPE: Metallic detectable type, three (3) inch wide plastic metallic type consisting of a color coded polyethylene or melinex film, a solid core aluminum detection layer and other layers recommended by the manufacturer to provide durability and longevity. The tape and ink shall be resistant to acids, alkalis and other components likely to be encountered in soils. Tape shall be color-coded blue, with repeating text “Caution Water

Pipeline Buried Below" or equivalent. Sentry Line Detectable Terra Tape by Reef Industries; Detectable Marking Tape by T. Christy Enterprises; or equal.

Provide electrical continuity connectors for end-to-end and branch connections: Terra Clips by Reef Industries; or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION OF DUCTILE-IRON PIPELINES: Except as specified herein or unless specifically authorized by the Engineer, all installation of pipe shall conform to the recommendations contained in "A Guide for Installation of Ductile-Iron Pipe," published by the Ductile Iron Pipe Research Association. A copy shall be available at the job site.

A. Pipe Laying: Pipe shall be laid with bell ends facing in the direction of laying, unless directed otherwise by the Engineer. Pipe shall be laid on the bedding with support over the full length of the pipe barrel.

Pipe joint deflections shall not exceed the amount shown in the following table.

DUCTILE-IRON PIPE DEFLECTION

Size of Pipe	Bend in One Joint	Deflection in One 18-Foot Length	Approx. Radius of Curve Produced by Succession of 18-Foot Joints
4"	4°	15"	250'
6"	4°	15"	250'
8"	4°	15"	250'
10"	4°	15"	250'
12"	4°	15"	250'
14"	2°	7.5"	510'
16"	2°	7.5"	510'
18"	2°	7.5"	510'
20"	2°	7.5"	510'
24"	2°	7.5"	510'

The information in the columns referring to the deflection and the approximate radii shall be adjusted for pipe lengths different than 18-foot lengths. To lay pipelines on curved alignment with shorter radius if called for on the Drawing, the Contractor will be required to use shorter pipe lengths. No increase in the proposal unit price shall be allowed for use of shorter pipe lengths. Double hubs may be used to lay pipelines on curved alignment.

Vertical deflections shall not exceed any of the above values.

When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or by other means approved by the Engineer.

The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or cement lining so as to leave a smooth end at right angles to the axis of the pipe. The flame cutting of pipe by means of

an oxyacetylene torch will not be allowed. The pipe end shall be beveled and free of sharp edges that could damage the gasket during installation.

B. Jointing of Mechanical Joints: The last 8 inches of the pipe spigot and the inside of the bell of the mechanical joint shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter from the joint, and then painted with a manufacturer supplied lubricant or soap solution made by dissolving one-half cup of granulated soap in one gallon of water. The cast-iron gland shall then be slipped on the spigot end of the pipe with the lip extension of the gland toward the spigot end. The gasket shall be painted with the lubricant or soap solution and placed on the spigot end of the pipe to be laid, with the thick edge toward the gland.

The entire section of the pipe being laid shall be pushed forward to seat in the spigot end of the bell of the pipe in place. The gasket shall then be pressed into place within the bell, being careful to have the gasket evenly located around the entire joint. The cast-iron gland shall be moved along the pipe into position for bolting, all of the bolts inserted, and the nuts screwed up tightly by hand. All nuts shall then be tightened with a suitable (preferably torque-limiting) wrench. The torque for various sizes of bolts shall be as follows:

Size (Inches)	Range of Torque ft. - lb.
⅝	45 - 60
¾	75 - 90
1	100 - 120
1¼	120 - 150

Nuts spaced 180 degrees apart shall be tightened alternately in order to produce an equal pressure on all parts of the gland.

C. Jointing of Push-On Joints: In jointing the pipe, the exterior 4 inches of the pipe at the spigot end and the inside of the adjoining bell and particularly the groove for the gasket shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter. The proper gasket supplied with the pipe shall be placed in the bell as described by the pipe manufacturer so it will spring into its proper place inside the pipe bell. A thin film of the pipe manufacturer's joint lubricant shall be applied to the gasket over its entire exposed surface. The spigot end of the pipe shall then be wiped clean and inserted into the bell to contact the gasket. Then the pipe shall be forced all the way into the bell by crowbar, or by jack and choker slings. The location of the gasket shall be checked with a gauge or tool designed for that purpose to assure that the gasket is in the proper position.

D. Installation of Polyethylene Encasement: When required, the polyethylene encasement shall prevent contact between the pipe and the surrounding backfill and bedding material, but is not intended to be a completely air and watertight enclosure. Overlaps shall be secured by the use of 2-inch wide, 10 mil thick, polyethylene pressure-sensitive tape.

Any of the three different methods for the installation of polyethylene encasement on pipe are acceptable as described in AWWA C105. Methods A and B are for use with polyethylene tubes and Method C is for use with polyethylene sheets.

All fittings shall be covered in the same manner as the pipe. Where appurtenances are odd-shaped, they shall be covered with flat sheet, wrapped with seams doubled over, and taped. Branch services and other extensions shall be provided for with an X-shaped cut in the film, then the ends taped in place. At connections with unwrapped pipe or service pipes, the polyethylene shall extend 3 feet onto the unwrapped pipe and securely taped in place. Repair any damage encasement prior to backfill using polyethylene sheet and adhesive tape to secure all edges of the repair sheet.

E. Conductivity Connections: The conductivity connection for joints shall be installed in accordance with the manufacturer's instructions. At each installation, before placing and welding the connection, the surface of the pipe shall be sanded free of its coating.

When completed, each conductivity connection shall be thoroughly coated with hot coal-tar enamel. The enamel shall cover the wire, the connection, and the pipe around the connection. Add polyethylene encasement when the pipe is sheathed.

F. Installation of Special Restrained Joints: Restrained-joint pipe and ductile-iron retainer glands shall be installed according to manufacturer's recommendations. Torque wrenches and any recommended special tools shall be used during installation. Any special tools shall be supplied to the Owner.

3.2 INSTALLATION OF PVC PLASTIC PIPE:

A. Pipe Laying: Pipe shall be laid with bell end facing in the direction of laying, unless directed otherwise by the Engineer. Deflection in the pipe joints will be allowed as long as it does not exceed manufacturer’s recommendations. Whenever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or to plumb valve operators, the pipe itself may be uniformly curved as shown in the table below.

Pipe Size C1.150	Offset in 20 foot length	Approximate Radius of Curve
4"	20"	120’
6"	15"	160’
8"	10"	250’
10"	8"	300’
12"	6"	400’

Pipe deflection for curvature shall not be permitted at temperatures less than 32^{o}F ambient temperature.

When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug.

The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe, and so as to leave a smooth end

at right angles to the axis of the pipe. Bevel the end of the pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field cut pipe.

Jointing the Pipe: The outside of the spigot and the inside of the bell shall be thoroughly wiped clean. Set the rubber ring in the bell with the marked edge facing toward the end of the bell. Lubricate the spigot end using a thin film of the manufacturer-supplied lubricant. Push the pipe spigot into the bell manually, with blocking and bar or with special jacks. Position the completed joint so that the mark on the pipe end is in line with the end of the bell. Pipe joint shall not be assembled using power or trenching equipment.

B. Tracer Wire: The tracer wire shall be made of 12-gauge stranded or solid copper, water-tight insulation for direct bury. The connector shall be solderless, 3M Direct Bury splice kit, or approved equal.

Tape the tracer wire to the top centerline of pipe every five feet with adhesive tape or plastic tie straps such that wire remains in place during embedding of pipe. Tracer wire shall be brought to the surface on the inside of a test station behind every fire hydrant. If PVC pressure pipe is being connected to any type of pipe other than plastic, the tracer wire shall be extended to the nearest fire hydrant.

After the tracer wire is installed, pass current through wire and demonstrate that wire is capable of locating the pipe. If wire will not pass current, locate break in circuit and test until tracer wire works in accordance with its intended use.

C. Warning Tape: Brightly colored warning tape shall be placed on the backfill above the pipeline, 2 feet below finished grade. Tape shall be continuous and shall not deviate outside the horizontal profile of the pipe.

3.3 INSTALLATION OF VALVES AND BOXES: Valves shall be installed where shown on the Drawings or as directed by the Engineer in the field and shall be set with the operator plumb. Valves shall have the interior cleaned of all foreign matter before installation. Stuffing boxes shall be tightened and the valves shall be operated to opened and closed positions to ensure that all parts are in working condition before installation. Installation and jointing procedures shall be similar to the attached piping installation. Special piping shall be used when required because of conflict with butterfly valve discs.

Unless otherwise noted, a valve box shall be provided for every valve. The box shall not transmit shock or stress to the valve or operator and shall be centered and plumbed over the operating nut of the valve, with the box cover flush with the surface of the finished grade or such other level as may be directed by the Engineer. The adjustable valve box shall permit at least 3 inches of adjustment either direction when in place.

3.4 INSTALLATION OF FIRE HYDRANTS: Fire hydrants and auxiliary gate valves shall be installed at the locations shown on the Drawings or as directed by the Engineer in the field. The exact location will be determined by the Engineer in the field. Concrete thrust blocks shall be installed at the hydrant and at the line branch tee. The hydrant shall be set on a base as shown on the detail Drawings, and a gravel drain provided. Fire hydrants shall be set plumb at the finished grade line, unless otherwise instructed by the Engineer.

No part of the fire hydrant assembly shall protrude over the edge of sidewalks. Unless in the opinion of the Engineer it is not practical to do so, the pumper nozzle (which shall be facing the street) shall be 12 inches behind the edge of the sidewalk. The hydrant shall be set with the traffic flange from 2-6 inches above finished grade. Each hydrant shall be operated to opened and closed positions prior to installation.

Fire hydrants shall come painted red from the factory.

3.5 EXTRA DEPTH EXCAVATION: In order to facilitate crossing under existing pipelines and other utilities, or as shown on the Drawings, the Contractor may be required by the Engineer to increase the depth of burial of new pipelines beyond design depth. No separate payment for extra depth will be made.

3.6 INSTALLATION OF THRUST RESTRAINT: The movement of fittings shall be restrained by use of concrete thrust blocks or steel clamp and tie bolt assemblies. The thrust blocks shall be poured between undisturbed solid ground and the fitting to be anchored; the area of bearing on the undisturbed trench wall shall be that shown on the thrust block detail or directed by the Engineer. The concrete shall be so placed that the pipe or fitting joints will be accessible for repair. Thrust blocks or other thrust restraint where thrust blocks cannot be used shall be required at all the fittings unless otherwise shown on the Drawings. A bond breaker shall be placed over the fitting before placing concrete.

Thrust restraint clamps and tie bolts shall be assembled using clamps on each side of pipe bells with tie rods extending full pipe length for the dimensions shown on the detail drawings each direction from the restrained fitting. Clamp shall be installed tight enough to prevent twisting around the pipe. Two tie bolts per clamp with washer at clamp shall be located on side of pipe. Tighten tie bolt nut to “hand-tight” with 12-inch wrench (approximately 50-100 foot - pounds torque). Threaded tie rod ends shall extend two full threads past nut in final position.

3.7 PIPE JACKING OR BORING: Where it is indicated on the Drawings, the pipe shall be installed by jacking or boring, or by any means required to accommodate soils conditions.

A. Safety: The sides of pits shall be supported by sheetpiling placed in such a manner as to prevent any movement or slippage of the earth during the excavation and jacking or boring operations. The Contractor shall work in close cooperation with the City of Lakewood to ensure the protection of all facilities within the jurisdiction of the City.

B. Jacking or Boring Pit: The jacking or boring pit shall be excavated on one side of the street under which the pipe or casing is to be installed. The pit shall be only of sufficient length to provide room for the boring machine or the jacking head, the jacking frame, the reaction blocks, the jacks, and one or two lengths of pipe, depending on the kind of pipe to be jacked or bored into place. The pit should be of sufficient width to permit ample working space.

C. Jacking Frame:

1. A jacking frame shall be constructed of guide rails, backstop, and pushing or jacking head. Guide rails shall be constructed to the exact line and grade of the pipeline and shall be anchored in such a manner as to be capable of maintaining the alignment and gradient throughout the jacking operation.

2. The backstop shall be so constructed as to provide a bearing area capable of supporting no less than 200 percent of the estimated maximum jacking pressure and shall be perpendicular to the centerline of the pipe to be jacked. It shall be anchored and braced in a manner to assure that this position will be maintained throughout the jacking operation.

3. The pushing or jacking head shall be constructed to fit the pipe to be jacked and to assure that the pressure developed by the jacks will be evenly distributed on the periphery of the pipe. An opening large enough to permit the entrance of men and materials shall be left and maintained in the jacking head.

D. Jacking Procedure: Depending on soil conditions, the excavation operation inside the pipe shall proceed approximately one foot ahead of the lead pipe. The excavation around the top and sides of the pipe shall be one inch larger than the periphery of the pipe. The bottom of the excavation shall be cut accurately to line and grade.

The Contractor shall use a pilot tube system, or other approved approach, to ensure that the bore is installed within ¼ inch of design line and grade.

3.8 INSTALLATION OF INSULATION: Pipe insulation, if the pipe must be laid shallow so as to avoid utilities, shall be installed in conformance with the manufacture's recommendations.

3.9 FLUSHING, TESTING, AND DISINFECTING:

A. Pipeline Flushing: The Contractor shall flush the pipelines as the work progresses by a means in accordance with good practice to ensure that sand, rocks, or other foreign material are not left in any of the pipelines. If possible, the flushing shall be made through an open pipe end; otherwise, use of a fire hydrant may be acceptable, but only on approval of the Engineer.

B. Pressure Test: After each section of pipeline has been laid and partially backfilled (except for the joints or when the Engineer directs the trench to be backfilled for reasons of public safety, or if the Contractor elects to backfill prior to testing, as permitted), the pipe shall be slowly filled with water and tested. All pipe shall be tested at a pressure of 150 psi at the lowest point in each section. Each section shall be tested separately, but outside transmission mains may be tested in convenient lengths. The duration of each pressure test shall be at least one continuous hour. All water used in testing the pipelines shall be taken from a potable water supply.

Each section of pipeline being tested shall be slowly filled with water and all air removed. The specified test pressure shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer. The Contractor shall furnish all necessary labor, equipment, and connection corporation stops to the pipeline to perform the test.

No testing shall be permitted against valves or fittings that are a part of the existing system unless specifically approved by the Engineer.

All exposed pipes, fittings, valves, hydrants, and joints will be carefully examined during the test. Any cracked or defective pipe, fittings, valves, or hydrants discovered during the

pressure test shall be removed and replaced by the Contractor with sound material. The test shall be repeated until it is satisfactory to the Engineer.

C. Leakage Test: A leakage test shall be conducted after the pressure test has been completed unless the pressure test indicates that there are no leaks. The Contractor shall furnish the valves, pipe, fittings, connections, meters, and all other necessary apparatus, and shall furnish all necessary assistance to conduct the test. The duration of each leakage test shall be two hours, and, during the test, the main shall be subjected to a hydrostatic pressure of 150 pounds per square inch.

No pipeline installation will be acceptable until the leakage is less than the amount computed by the following formula:

1. DIP, PVC $L = \frac{SD(P)^{0.5}}{133,200}$

L = Allowable leakage in gallons (per hour)
S = Tested length of pipe (feet)
D = Nominal diameter of pipe (inches)
P = Average test pressure during the test (psi)

Should any test of pipe laid disclose leakage greater than that specified above, the Contractor shall, at its own expense, locate and repair the points of leakage until the leakage is within the specified allowance.

The pipe may be subjected to hydrostatic pressure, inspected, and tested for leakage at any convenient time after the trench has been partially backfilled, except at the joints, or backfilled as permitted by the Engineer. Where any section is provided with concrete thrust blocks, the pressure test shall not be made until at least two days have elapsed after the concrete was installed.

The Engineer shall be notified at least 48 hours before the pipe is to be tested so that he may be present during the test.

D. Disinfecting: All water piping installed under this Contract shall be disinfected in accordance with AWWA C601 after all construction work has been completed. Chlorine shall be added to the water at the necessary locations in the amount to form a 50 ppm free chlorine residual. The chlorine solution shall be left in the pipelines for not less than 24 hours, during which time all valves and fire hydrants shall be operated in order to disinfect the appurtenances. After that length of time, the chlorine residual of the solution at any place in the system shall not be less than 10 ppm. As required, the Contractor shall make all necessary taps for inserting the chlorine solution in the pipeline and venting and draining pipelines using approved corporation stops. After the disinfection has been completed and approved, the corporation stops shall be closed, left in place, and sealed with a cap. All chlorination work must be done under the supervision of the Engineer. At the end of 24 hours, a bacteriological test is to be performed by the local health authority to ensure adequate disinfection.

After approval of the disinfection operations, the Contractor shall flush the new system until the chlorine residual is 0.3 ppm and a clear water test made.

E. Electrical Conductivity Test: When required by the Contract Documents, the Engineer will require that the pipe is tested to determine whether or not satisfactory electrical conductivity has been established. The pipe shall conduct at least 300 amperes at 16 volts for a 200-foot section of pipe. No pipe section will be accepted if it does not satisfactorily conduct the electricity stated.

The Contractor shall furnish all necessary labor and materials to conduct the test including electric welder and sufficient length of conductor to connect to the ends of a test section.

3.10 CONNECTIONS TO THE EXISTING SYSTEM: The existing system must at all times remain under the control of the Owner. The Contractor shall operate no valves or hydrants on the system without permission of the Owner.

All points at which the existing water systems are to be disconnected and connected to the new mains are shown on the Drawings. Connections to the existing system shall be completed after new pipeline, valves, thrust blocks, and other appurtenances are installed and tested. Connections shall be done in accordance with the details given for each point of disconnection or reconnections. At each point of connecting new pipes to existing pipes, the Contractor shall expose the existing pipe and locate a good sound point at which to cut the existing pipe off square. The Contractor shall then provide and install a transition coupling which has been designed and manufactured explicitly for the purpose of joining together the two types and sizes of pipe which he must connect. The use of poured concrete collar connectors around two dissimilar sizes or types of pipes without the use of the proper transition couplings will not be permitted.

For addresses where the water meter is located inside a building, the Contractor shall remove the existing meter, salvaged, and returned to the Owner. Install a new meter pit and appurtenances, provided by the Owner, outside, set back at least two feet from the sidewalk/property line, in accordance with the detail drawing.

When installing tapping sleeve, the Contractor shall take all precautions and follow the instructions provided by the Manufacturer.

The Contractor shall take precautions as necessary to minimize interruption of all utility services and will be responsible for restoration of service.

Unless otherwise specified, at any time that a customer on the existing system will be deprived of a supply of water, the Contractor shall advise such customer at least 24 hours in advance when the supply will be discontinued and when the supply will again be available. Service shall not be disrupted for more than a four-hour period.

- END OF SECTION -

PART 1 -- GENERAL

1.1 SCOPE: The work of this section includes providing and installing Polyvinyl Chloride pipe, and fittings for sanitary sewer service mains and laterals. All materials shall be new and the best available. All material used shall be manufactured and supplied according to the latest revised standards of the American Water Works Association, the American National Standards Institute, and the American Society for Testing and Materials, or as mentioned hereinafter. Miscellaneous valves and fittings shall be as called out on the Drawings.

1.2 REFERENCES:

A. American Society for Testing and Materials (ASTM)

B. American National Standards Institute (ANSI)

C. American Water Works Association (AWWA)

D. Federal Specifications (FS)

1.3 CONTRACTOR SUBMITTALS: In accordance with Section 01300, submit:

A. Certificate of compliance

B. Manufacturer's literature and product data sufficient to demonstrate compliance with the specified requirements.

C. Manufacturer's installation instructions and recommendations.

D. Test results.

1.4 PRODUCT HANDLING:

A. Pipe, fittings, and all other accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage to them. Under no circumstances shall any materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground. Skidding which damages protective coatings will not be permitted.

In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench to minimize moving more than once.

All pipe and fittings shall be so handled so that the coating and lining will not be damaged. If any part of the coating or lining is damaged, the repair shall be by the Contractor, at its expense, in a manner satisfactory to the Engineer. Any area damage beyond repair must be cut off and discarded.

B. All pipe will be field inspected at the job site and checked for conformance to these specifications. Pipe and fittings will be checked for out-of-round or damaged joints, interior and exterior surface damage, gasket damage and the other requirements listed herein. Any pipeline or appurtenant material found defective will be rejected. Any

material rejected at the job site shall be marked “Rejected” and the Contractor shall remove it immediately from the job site.

The Contractor shall provide results of tests required by the various standard specifications listed herein. The Contractor will not be reimbursed for the pipe tested, the testing, or for the reports submitted to the Engineer.

The Contractor shall provide the Engineer with two copies of the standard specifications covering the manufacture and testing procedures of the pipelines and other materials. The submittal shall be made prior to delivery of the materials.

C. Do not store materials directly on the ground. Polyvinyl chloride (PVC) pipe shall be stored under opaque cover that does not transmit UV light.

PART 2 -- PRODUCTS

2.1 PIPELINE MATERIALS:

A. General: The Contractor shall install the pipeline material according to the requirements by pipeline size (below) or as designated on the Drawings. The Contractor shall furnish pipeline materials that meet applicable requirements of this Specification.

1. Polyvinyl Chloride Pipe (PVC), 27 inches or less.

The internal diameter of the pipe shall not be less than the diameter shown on the drawings.

B. Polyvinyl Chloride Pipe: The 4 to 15-inch diameter pipe shall be type PSM polyvinyl chloride pipe (PVC) suitable for gravity sewer service. The pipe material shall be made of PVC plastic having a cell classification of 12454-B, 12364-C, 12454-C, or 13364-B (with a minimum tensile modules of 500,000 psi) as defined in ASTM D1784. All PVC pipe and fittings shall meet or exceed all of the material requirements of ASTM D3034 and minimum thickness requirements of SDR-35 (4-inch to 15-inch diameter). Where called for on the drawings or required by the Engineer, the PVC pipe and fittings shall meet or exceed the thickness requirements of SDR-26, PS115 and ASTM F679. The pipe material shall be integrally pigmented green in color.

The 18 to 27-inch diameter pipe shall be polyvinyl chloride suitable for gravity sewer service with the PVC having a cell classification of 12454-C as defined by ASTM D1784. The pipe shall conform to the requirement of ASTM F679 (latest revision) with dimensions, pipe stiffness, and minimum wall thickness, T-1, designated in Table 1. The pipe material shall be integrally pigmented green in color.

Provisions must be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. Gaskets shall conform to ASTM F477. Pipe shall be supplied in nominal laying lengths of 20 feet. All pipe and fittings shall be assembled with a non-toxic lubricant. Each length of pipe and all fittings shall have marked on the exterior the following:

1. 4-inch to 15-inch

    a. Manufacturer's Name or Trademark
    b. Nominal Pipe Size
    c. PVC Cell Classification (e.g. 12454-B)
    d. Legend - Type PSM SDR-35 Sewer Pipe
    e. ASTM-D3034

2. 18-inch to 27-inch

    a. Manufacturer's Name or Trademark
    b. Nominal Pipe Size
    c. PVC Cell Classification (e.g. 12454-C)
    d. Pipe Stiffness Classification: PS 46 PVC Sewer Pipe
    e. ASTM F679

All fittings to be used with the PVC pipe shall be those manufactured by the manufacturer of the pipe. Each special fitting shall be a completely manufactured unit with either bells or spigots on each connection that are an exact duplication of the bells and spigots on the pipeline. Fittings with any other type of connections will not be accepted.

2.2 CONCRETE: Concrete for encasing the sewer pipeline, manhole bases, securing clean-out access castings, and other similar items shall have a 28-day compressive strength of not less than 3,000 psi. All reinforcement required shall be standard deformed reinforcement conforming to the requirements set forth in ASTM A615, Grade 60.

2.3 MISCELLANEOUS:

A. Plugs: Plugs shall be specifically manufactured for the pipelines in which they are to be installed. The plug shall be constructed of a material approved by the Engineer and shall provide a permanent water-tight installation without permanently sealing the joint.

B. Couplings: Couplings shall be used only where shown on the drawings or where approved in writing by the Engineer. The Contractor shall provide a description of and exact location of any couplings used.

Flexible couplings shall consist of a rubber gasket or boot, stainless steel shear ring, and 300 series stainless steel tightening bands. The coupling shall conform to requirements of ASTM C425 and shall be "Mission" ARC or approved equal.

C. Fittings: Fittings shall be of the same material and meet the same requirements, including coatings and linings, as the pipeline in which they are installed.

The fittings shall be standard manufactured form with the same type of joint as the pipe.

D. Grout: Grout shall be a non-shrink type with aluminum filings; grouts with iron filings are not acceptable. Grout shall be "Five Star Grout," "Embeco Grout" or equal. The

Contractor may substitute a 2-component, 100% solids epoxy resin (Sikadur Hi-Mod LV) for the specified grout.

Grout used for sealing service connections shall be a 2-component, waterproof epoxy grout specifically manufactured for this application. The grout shall adhere to any of the dissimilar materials.

E. Sealants: Sealants used on manholes or pipe connections shall be equal to SIKAFLEX-la, a one component polyurethane base, elastomeric sealant. When required due to moisture or immersion, provide SIKAFLEX 429 primer for application onto the substrate according to manufacturer's recommendation.

2.4 SEWER SERVICE LINES: Sewer service lines, including joints and plugs, shall be constructed of materials as specified for the sewer mains. Sewer service lines shall connect to the sewer main at either a tee or wye, unless specifically permitted by the Engineer, then the Contractor will be allowed to use saddles.

Saddles shall be manufactured of the same materials as the sewer pipeline or of PVC. Saddles shall provide for a right-angle entry into the sewer main. The saddle shall be contoured to fit the sewer main pipe and shall be permanently attached thereto with an epoxy glue or stainless steel bands. Saddles shall be specifically constructed to connect the service line to the main line without modification of either.

PART 3 -- EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS: Each pipe length, fitting interior, interior surface of bells, and exterior surface of spigots shall be cleaned of all foreign material before placing it in the trench and shall be kept clean all times thereafter. Each item must also be examined for cracks and other defects before installation.

Pipe shall be cut, only whenever necessary, to conform to location of manholes or connections. All cuts shall be straight, true, and at right angles to the axis of the pipe unless otherwise noted or directed by the Engineer. The cutting process shall leave a smooth end without damaging the pipe. All burrs shall be removed from the ends of cut pipe and the end shall be lightly rasped or filed. All tools used in cutting pipe shall be subject to the Engineer's approval.

Pipe laying shall proceed upgrade with the spigot ends of pipe pointing in the direction of the flow, unless otherwise approved by the Engineer. Each pipe length shall be laid true to line and grade in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets to the flow line. Pipe shall be laid in a dry (dewatered) trench and shall not be used for draining water from the trench.

Whenever the pipe is left unattended or pipe laying is not in progress, temporary plugs shall be installed at all openings. Temporary plugs shall be watertight and of such design as to prevent debris and animals from entering the pipe. All temporary plugs shall be subject to approval of the Engineer.

The Contractor shall obtain from each pipe manufacturer complete installation instructions. The Contractor shall provide the Engineer with two copies of those instructions and shall have additional copies at the site of the work. The Contractor shall install the materials in accordance

with the manufacturer's recommendations. If there is a conflict between the Contract Documents and the manufacturer's instructions, the Contractor shall obtain resolution from the Engineer before proceeding with the work.

3.2 INSTALLATION OF PVC PLASTIC PIPE:

A. Pipe Laying: No deflection in the joints shall be allowed. All pipe shall be fully supported by the full length of pipe barrel without support by the bell mounding.

When curved sewers are indicated on the drawings, the alignment curve shall be accomplished by installing the pipes on uniform curves by deflecting the pipe barrel. The minimum curves are shown below:

Pipe Diameter Inches	Minimum Radius Feet	Offset 20' length Inches
4	150	16
6	200	12
8	250	10
10	300	8
12	350	7
15	400	6

B. Jointing the Pipe: The outside of the spigot and the inside of the bell shall be thoroughly wiped clean. Set the rubber ring in the bell with the marked edge facing toward the end of the bell. Lubricate the spigot end using a thin film of the manufacturer-supplied lubricant. Push the pipe spigot into the bell. Position the completed joint so that the mark on the pipe end is in line with the end of the bell.

Bevel the end of the pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field-cut pipe.

C. Connection of PVC Pipe to Concrete Manhole Base: The PVC pipe shall be encased in the concrete of the manhole base as detailed on the Drawings and special provisions shall be made for watertightness of the connection as follows:

The exterior circumference of the PVC pipe where encased in concrete for watertightness shall be uniformly roughened or scarified by sanding with coarse sandpaper or emery cloth for the encased length.

Additionally, a gasket or O-ring shall be stretched onto the PVC pipe to form a weep ring where encased in concrete. The gasket shall be specifically manufactured for this purpose and shall have a stainless steel ring to hold it securely around the pipe. The gasket shall be supplied by the pipe manufacturer.

Any proposed alternative to the above-specified methods for PVC pipe connection to concrete shall be submitted to the Engineer for approval prior to use.

3.3 PROTECTION OF TREATED WATER PIPELINES: When the location of the treated water pipelines is not known and no specific protection is set forth on the Drawings or in the construction requirements, the Contractor shall be governed by the following instructions:

A. When a sanitary sewer pipeline crosses an existing water pipeline and the sewer is above or less than a clear distance of 18 inches below the water pipeline, the Contractor shall encase the sewer pipeline in a concrete encasement, constructed in accordance with the details set forth on the Drawings. The length of the encasement shall be such that the un-encased sewer pipeline is not less than 10 feet horizontally on both sides of the water pipeline.

B. When a sanitary sewer pipeline is found to be less than 10 feet horizontally from a water pipeline which is parallel or converging to the sewer pipeline, and the sewer alignment cannot be moved to an approved new alignment at least 10 feet from the water pipeline, then the Contractor shall encase the sewer pipeline in a concrete encasement, constructed in accordance with the details set forth on the Drawings for the distance that the sewer pipeline is less than 10 feet from the water pipeline.

3.4 PIPE ENCASEMENT: Where shown on the Drawings or as determined by the Engineer, the pipeline shall be encased with concrete in accordance with the details set forth on the Drawings.

When specifically authorized by the Engineer, an encasement alternative may be permitted if submitted and approved. For potable water pipeline crossings, a 20-foot length of specified PVC Class 200 or DIP Class 52 may be installed. Center the 20-foot length on the water pipe with watertight transition couplings for connections to the sewer.

3.5 FLUSHING AND TESTING SEWER PIPELINES:

A. Pipeline Flushing: The Contractor shall flush the pipelines, as the work progresses, by means that are in accordance with good practice, to insure that earth, sand, rocks or other foreign materials are removed from the interior of the pipeline.

B. Alignment and Grade: Sewer pipelines will be checked by the Engineer to determine whether any displacement of the pipe has occurred after the trench has been bedded to an elevation 6 inches above the pipe and tamped as specified. The test will be as follows:

A light will be flashed between manholes, or if the manholes have not as yet been constructed, between the locations of the manholes, by means of a flashlight or by reflecting sunlight with a mirror. If the illuminated interior of the pipeline shows poor alignment, displaced pipe, earth, or other debris in the pipe, or any other kinds of defects, the defects, determined by the Engineer, shall be remedied by the Contractor at their own expense. The test will be repeated following completion of backfilling and any poor alignment, displaced pipe, or other defects, determined by the Engineer, shall be corrected at the Contractor's expense.

Curved sewers shall be cleaned with a heavy rubber ball after the pipe has been laid and the backfill has been placed. The rubber ball shall be similar and equal to a "Mac Wane Ball," as manufactured by the Sidu Company, Long Beach, California. The ball

shall be inflated and the outside diameter shall be the same as the inside diameter of the sewer pipe. The ball shall be placed at the upper manhole of the sewer reach to be cleaned. A head of water shall be placed against the ball to force the ball through the sewer, and debris flushed from the line shall be collected at the lower manhole, or its location. The ball shall be secured by a line to control the rate at which the ball is allowed to pass through the sewer.

C. Leakage: Tests for watertightness shall be made by the Contractor in the presence of the Engineer. The Contractor shall provide assistance to the Engineer in development of a detailed record of the testing program. The sewer and connections shall not leak in excess of the following rate for a 24-hour test period:

MAXIMUM ALLOWABLE SEWER LEAKAGE

Pipe Size Inches	Leakage Gal/Foot/24 Hours
36	1.36
30	1.14
27	1.02
24	0.91
21	0.80
18	0.68
15	0.57
12	0.45
10	0.38
8	0.30
6	0.23

Each reach of pipeline between manholes shall be tested individually. Any individual reach that leaks in excess of the amount allowed in the previous paragraph shall be considered as failing, and shall be repaired and retested.

At the discretion of the Engineer, the time for leakage rate test may be shortened to four (4) hours.

The tests and measurement of infiltration or exfiltration shall be conducted in a manner as approved by the Engineer. The Contractor shall repair the sewer in a manner that is satisfactory to the Engineer and re-test until satisfactory tightness is obtained.

Infiltration tests will be used if the groundwater table is 1 foot or more above the finished sewer; otherwise, exfiltration tests will be used. The minimum head for the exfiltration tests shall be 2 feet above the top of the pipe at its highest point in the test section. Sections shall be bulk-headed so that during any test the head on the sewer at its lowest elevation will not be more than 10 feet. This restriction does not apply to ductile-iron pipe. In any section of the pipeline if the head at the lowest point in the section exceeds 10 feet, then the Engineer will set forth the special method of testing to meet the field conditions.

Air tests for sewer lines may be substituted for leakage tests at the option of the Contractor. The air tests shall be conducted in the presence of the engineer, or his authorized representative, in accordance with the guidelines and standards set by Uni-Bell Plastic Pipe Association.

The Contractor will use equipment specifically designed for air testing sewers. The air test shall be made when the sewer is clean and lateral services properly plugged. The line shall be plugged at each manhole with pneumatic balls and low pressure air may be introduced through either end. The air shall fill the plugged line until the internal pressure is 3.5 psig greater than the average back pressure of any groundwater pressure that may submerge the pipe. (This pressure to be determined in the field by the Engineer, but not to exceed 9.0 psig). At least two (2) minutes shall be allowed for the air temperature to stabilize, then the internal pressure shall be allowed to drop to the test pressure. At this point the internal line pressure is monitored. The line pressure shall not drop more than 0.5 psig in less time than specified in the table or the pipe fails the test and shall be repaired and retested. The Contractor is responsible for locating the leaks, repairing them, and re-testing the line.

Air Test C Minimum Time Pressure Loss

Pipe Diam. (In)	Minimum Time (Min:Sec)	Length Pipe (Ft)	Time Longer for Length (Sec)
8	3:47	298	.760 L
10	4:43	239	1.187 L
12	5:40	199	1.709 L
15	7:05	159	2.671 L
18	8:30	133	3.846 L
21	9:55	114	5.235 L
24	11:20	99	6.837 L

D. Deflection: All PVC sewer pipelines shall be tested for vertical deflection after placement and compaction of backfill unless testing is specifically accepted by the Engineer. Method of testing shall be by deflectometer of the rigid GO/No-GO type device. An alternative method will be permitted only by written permission of the Engineer or as defined in the Special Construction Provisions of these Specifications. Maximum allowable deflection shall be five percent (5%) per cent of the pipe diameter. Any and all pipe with vertical deflection greater than the allowable shall be excavated, removed from the pipeline, replaced, backfilled and compacted as specified, and retested at the Contractor's expense.

3.6 SEWER SERVICE PIPELINES: When new sewer service pipelines or reconnection of existing services are to be installed as a portion of the Contract, these pipelines are to be installed in accordance with the details set forth on the Drawings and with appropriate installation requirements of this Specification.

The general locations of the service lines are shown on the Drawings. Actual locations of these pipelines are to be determined in the field by the Contractor based on video inspection prior to construction.

The Contractor will be allowed to tap and install a service saddle to sewer pipelines only at locations approved by the Engineer. Connections shall be made only by boring or drilling with equipment designed for this purpose. Connections shall not be made by impact equipment. The Contractor shall request, in writing, the Engineer's approval of methods and equipment proposed for the connections.

The Contractor shall remove from the pipeline all debris created by making connections before the service line is connected.

Service line saddle connections shall be attached to the main line with an epoxy bonding agent. The bonding agent shall be applied to a clean, dry surface. The connection shall remain dry until the bonding material has set, depending upon environmental conditions. Backfill around the connection shall not be attempted until the material has hardened and been accepted by the Engineer or Owner. The Contractor shall repair any damage to the main pipeline lining after the connecting PVC saddle has been bonded to the pipe. The lining shall be repaired with materials furnished by the manufacturer of the main pipeline.

The Contractor shall connect new service pipelines to fitting or saddle with the same material as the existing. Flexible couplings shall be used only to connect dissimilar piping materials or reconnecting existing services.

- END OF SECTION -

PART 1 -- GENERAL

1.1 SCOPE: The work required under this Specification consists of furnishing all labor, materials, and performing all construction operations in connection with installation and erection of precast concrete manholes, vaults and all related embedded and attached items.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. Concrete Work – Section 03050

1.3 DESIGN: Precast vaults shall be designed to accommodate the following loads:

A. H-20 vehicle load.

B. A superimposed load of 18 inches of soil cover.

C. A superimposed point live plus dead load above the valve of 1200 pounds.

Openings shall be provided as shown on the Drawings and may be cast or core drilled; percussion drilling shall not be used. Pipe openings shall be of sufficient diameter to accommodate the pipe and sealing grout. The roof opening(s) shall have additional reinforcement, set of 45º from the edges of the vault and extending 2 feet beyond the opening(s).

For pressure reducing valve and other vault(s), the roof slab shall be at least 8-inches thick and the walls at least 6-inches thick. The wall reinforcement shall have a clear distance of 1 inch from the inner face of the vault.

Vault design shall include installation of ladders and piping supports

1.4 CONTRACTOR SUBMITTALS: In accordance with Section 01300, furnish manufacturer's literature on precast sections, joint material, frame and cover, ladder, and steps. Submit shop drawings showing details of construction and design calculations signed and sealed by an Engineer licensed to practice in the State of Colorado.

PART 2 -- PRODUCTS

2.1 GENERAL: Manholes and vaults shall be constructed of pre-cast concrete riser sections, in accordance with the details shown on the Drawings. The concrete sections shall conform to ASTM C478. The top section required for change of diameter shall be eccentric cone or flat slab if permitted by the Engineer.

To bring the manhole cover to the correct elevation, the adjustment section of each manhole shall be pre-cast concrete. These rings shall not be less than 6 inches wide and furnished in heights to allow for 1-inch adjustment. Maximum adjustment height shall not exceed 12 inches.

Gaskets for connecting PVC pipe to manhole sections shall be specifically manufactured for that purpose. The gasket shall be provided by the pipe manufacturer.

Stubs shall be provided at manholes when shown on the Drawings. Stubs shall be sealed with a removable watertight plug.

All bolts and washers, connectors, fasteners and miscellaneous metal work shall be fabricated from stainless steel, Type 316, (B8M, B8MA) in accordance with ASTM Standard A-193.

2.2 JOINTS: Precast manhole joints shall be made watertight with Rub R-Nek material or equal. Diameter of gasket shall be as recommended by the manufacturer.

2.3 FRAME AND COVER: Frames and covers shall be 24-inch diameter as manufactured by D and L Supply (Number E1926), or equal.

The PRV vault manway access frames and covers shall be aluminum with 4-inch high frame, 32-inch diameter, manufactured by Castings, Inc., model number MH-550-32 RT-AL, or approved equal.

Covers shall have the word "SANITARY SEWER" or “WATER” clearly cast on its surface.

2.4 STEPS/LADDERS: The manhole steps shall be copolymer polypropylene with 1/2-inch grade 60 reinforcement as manufactured by M.A. Industries or equal. Manholes over 15 feet depth and vaults shall have a stainless steel ladder similar to Halliday L1D with non-slip rungs, or equal.

2.5 GROUT: Grout shall be non-shrink type with aluminum filings; grout with iron filings are not acceptable. Grout shall be "Five Star Grout," "Embeco Grout" or equal.

2.6 CONCRETE: Concrete for cast-in-place manhole bases shall have a 28-day compressive strength of not less than 3,000 psi. The maximum water content shall be 0.5 pounds of water per pound of cement. Entrained and entrapped air shall be between 4 and 9 percent. All reinforcement shall be standard deformed reinforcement conforming to the requirements set forth in ASTM A615, Grade 60.

Concrete for cast-in-place vault bases shall have a 28-day compressive strength of not less than 4,500 psi. The maximum water content shall be 0.5 pounds of water per pound of cement. Entrained and entrapped air shall be between 4 and 9 percent. All reinforcement shall be standard deformed reinforcement conforming to the requirements set forth in ASTM, A615, Grade 60.

2.7 INTERIOR DROP: The interior drop manholes, where required, may be completed using an alternate interior drop bowl, similar or equal to that manufactured by Reliner/Duran Inc. The bowl shall be of fiberglass construction and include the force line hood. The bowl shall include all stainless steel hardware and stainless steel pipe clamping brackets. The brackets (minimum 3) shall be adjustable and ordered to fit sewer pipe as shown on the Drawings. The drop pipe shall be constructed of SDR 26 sewer pipe with the long radius 90° bend outlet formed into the manhole base. Manholes shall be 6 feet diameter for inside drops.

PART 3 -- EXECUTION

3.1 GENERAL: Manholes shall be constructed to conform to the details shown on the Drawings. The invert channels shall be smooth and semi-circular in shape, conforming to the inside of the incoming and outgoing sewer pipelines. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size

and grade of the channels shall be made gradually and evenly. Where differences in invert elevations exist, sloped flow channels shall be formed so the sewage does not undergo a vertical drop. The invert channels may be formed directly in the concrete of the manhole base. The floor of the manhole outside of the channel shall be smooth and shall slope toward the channels at not less than 1 inch per foot and not more than 2 inches per foot. The manhole covers shall be set with their tops at the ground line, compacted backfill shall be placed around the exposed section as shown on the Drawings. The site shall be graded so that drainage is away from the manhole.

Outside each manhole or vault, where the pipe enters/exits, within 12 inches of the manhole base, the Contractor shall install a bell section of pipe or a certified and accepted coupling as indicated on the Drawings.

Each joint of the precast manhole barrel shall have at least one continuous gasket placed on the lower ledge before the barrel immediately above is lowered into place.

3.2 GROUTING: Any opening between manhole walls and pipe made by the Contractor, and lifting holes or as designated elsewhere, shall be closed watertight with grout. The opening shall be of sufficient size to accommodate the pipe, "O"-rings, and grout. The grout shall extend no less than the full width of the manhole barrel. Use grout to make a watertight seal in and around existing pipes which are removed from service.

Channels that have been cut into existing concrete bases shall be smoothed to the specified contour with grout.

3.3 TESTING: During the construction of the manholes and vaults, the Contractor shall, in accordance with good practice, ensure that no earth, sand, rocks, or other foreign material exists on the joint surfaces during assembly of the sections. The Engineer shall check each manhole to determine whether the manhole fulfills the requirements of the Drawings and Specifications. The Visual Examination and either the Leakage Test or Vacuum Test are required.

A. Visual Examination: The Engineer shall visually check each manhole, both exterior and interior, for flaws, cracks, holes, or other inadequacies which might affect the operation or watertight integrity of the manhole. Should any inadequacies be found, the Contractor shall make any repairs deemed necessary by the Engineer.

B. Leakage Test: All manholes shall be tested for leakage and all tests shall be witnessed by the Engineer. The leakage test shall be conducted prior to backfilling around the manhole and shall be carried out in the following manner:

1. All lines leading into or out of the manhole shall be tightly plugged.

2. The manhole shall be filled with water to a level at least 2 inches above the uppermost step. The water shall be allowed to stand for two hours to allow for normal water absorption into the manhole material. At the end of the two-hour stabilization period, if the water level in the manhole has dropped below the top step, additional water will be added to bring the level above the step as before. Any visible external leakage or drop in water level noted within the one-hour test period shall constitute failure and the Contractor, at its own expense, shall repair the manhole and re-test until satisfactory watertightness is obtained.

C. Vacuum Testing: All pipes entering and exiting the manhole shall be temporarily plugged, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole.

The test head shall be placed at the top of the manhole and the seal inflated in accordance with the manufacturer's recommendations.

A vacuum of 10-inches of mercury shall be drawn on the manhole, the valve on the vacuum line of the test head shall be closed, and the vacuum pump shut-off. The time shall be measured for the vacuum to drop to 9-inches of mercury.

The manhole will be declared unacceptable if the time to drop from 10-inches of mercury to 9-inches of mercury is less than the time shown in the following table:

DEPTH (FEET) (Vertical Length of Manhole)	TIME (seconds)		
	48" Diameter	60" Diameter	72" Diameter
8	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121

The minimum test time shall be one minute. If the manhole fails the initial tests, the manhole shall be repaired and re-tested until a satisfactory test is obtained.

- END OF SECTION -

