SECTION 4 - MATERIALS, TESTING AND INSTALLATION

4.1. GENERAL

All sanitary sewer system materials, construction and testing shall be in accordance with these Specifications. Any material proposed as "an equal" must be reviewed and found acceptable by the District prior to design or construction unless specified otherwise by the District. PVC pipe material (as defined in Section 4.2 and 4.3) shall be used for sanitary sewer system construction.

4.2. PIPE MATERIAL

Sanitary sewer pipe and fittings shall be polyvinyl chloride (PVC) conforming to ASTM D1784 *Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds* shall meet one of two sets of requirements as stated below:

1. SDR-35 pipe meeting ASTM D3034 *Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings* or ASTM F679 *Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings* latest revision.

2. DR-18 pipe meeting AWWA C900 *Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In., For Water Distribution* or AWWA C905 *Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In., For Water Transmission and Distribution* latest revision.

Pipe and fitting markings shall include the appropriate ASTM and Cell Classification Numbers (12454-B or 12454-C or other ASTM approved classifications) and be GREEN in color. Unmarked pipe and fittings will be rejected.

Pipe selection will be determined based on location and depth of sewer pipe. Table 4.1 below outlines pipe selection requirements. The entire sewer segment between manholes shall be of the same material.

Table 4.1 - Sanitary Sewer Pipe Selection

Location	Depth	Pipe Material
Public Right-of-Way	<= 18’	SDR-35
	> 18’	C900/905 DR-18
Easement (Unpaved)	<= 18’	C900/905 DR-18
	> 18’	
Easement (Paved)	<= 18’	SDR-35
	> 18’	C900/905 DR-18
Steel Casing (Creek crossing, jurisdictional/owner requirement, District determination)	<= 18’	C900/905 DR-18 (All joints in casing to be fused or restrained using internal restraint device)
	> 18’	

4.2.1. PIPE THICKNESS CLASS

Sewer pipe shall be either DR18 or SDR35 as outlined in Section 4.2 unless otherwise specified by the District.

4.2.2. STRAIGHTNESS

Maximum allowable curvature as measured from the concave side of the pipe shall not exceed 1/16" per foot of length.

4.2.3. LAYING LENGTHS

PVC pipe shall have normal laying length of either 18 or 20 feet. Random lengths shall not be acceptable.

4.2.4. PIPE JOINT TYPE

PVC joints shall be made using an integral bell and spigot type rubber gasketed joint. Each integral bell joint shall consist of a formed bell and a single rubber gasket. Gaskets shall conform to ASTM F477.

In cases where pipe joints are required to be restrained the pipe shall utilize an internal restraint system suitable for C900/905 PVC pipe such as the Bulldog Restraint System or approved equal.

4.3. POLYVINYL CHLORIDE (PVC) PIPE

4.3.1. INSTALLATION AND TESTING

See Sections 4.12 and 4.13 of these Specifications.

4.4. SANITARY SEWER PIPE FITTINGS

4.4.1. FITTINGS AND BRANCHES

Branches of the size and type shown on the reviewed and signed Construction Plans shall be furnished for service connections. In line "wyes" are the only fittings acceptable for service connections to new construction and shall be of equivalent standard as the main pipe it is installed on. "Wye" branches shall have their axis approximately 45° (unless otherwise specified on the plans) to the longitudinal axis of the pipe. All branches shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the branch socket.

Service connections to existing PVC pipe requires the use of a long body style "wye" saddle and rubber gasket secured to the pipe using double stainless steel straps.

Secure connections to existing concrete or vitrified clay pipe require the use of a PVC "wye" saddle and rubber gasket secured to the pipe with double stainless steel straps. The service connection shall be encased in concrete.

4.4.2. PLUGS

Pipe plugs shall be 3/4" in thickness and shall have a factory-made plasticized polyvinyl chloride compound joint material cast and bonded to the pipe. The material shall be molded and cured to a uniform hardness and compressibility, and form a tight compression coupling when assembled. The material used for the compression joint shall conform to the type of pipe material specified.

Neoprene (synthetic rubber) plugs shall be equal to those manufactured by Gladding McBean and Company or equal. The joint formed by the plug and pipe shall be a tight compression coupling when assembled.

4.4.3. INSTALLATION AND TESTING

Fitting installation shall be in accordance with the manufacturer's recommendations and Sections 4.6, 4.12.6 and 4.13 of these Specifications.

4.5. MANHOLES

4.5.1. GENERAL

This Section outlines the material and installation requirements for manholes. Excavation, foundations and backfill requirements are described in Section 4.12. All manhole structures shall be designed for H-20 traffic loading in accordance with AASHTO Specifications.

Generally, manholes shall be constructed using pre-cast sections. Cast-in-place manhole bases are allowed only when practicable by construction. Examples of such installations are when new infrastructure is to connect to existing pipeline with a new manhole.

Riser sections (barrel sections) shall be pre-cast reinforced concrete. Top sections shall be eccentric cone and shall comply with ASTM C478. All precast sections shall have the date of manufacture and the name and trademark of the manufacturer clearly marked on the inside of each section. Manholes shall be in accordance with the Detail Drawings.

Manhole sections shall not be shipped or subjected to loading until the concrete compressive strength has attained a minimum of 3,000 psi, and not before 3 days after fabrication and/or repair, whichever is longer.

4.5.2. PRE-CAST CONCRETE BASES

Manhole base slabs for manholes constructed along new sewer mains shall be pre-cast. Material Specifications for pre-cast bases are as follows:

- Minimum 4000 psi concrete 28-day compressive strength manufactured using Type II cement.
- All base and barrel sections shall be poured monolithically. Reinforcement shall include a complete rebar cage with #4 bars on 12-inch centers.
- All areas of seam tears, cracks and honeycombs shall be patched and resurfaced prior to final curing.
- Prior to coring the pipe openings and installing the pipe connection boot, all exposed reinforcing shall be coated with coal tar or epoxy paint.

- Pipe boots or gaskets are to be placed in the cored openings shall be manufactured by Forsheda (Model F-910), or approved equal, meeting all ASTM C923 requirements. Boots and gaskets may be precast in to the manhole base if installed in the field.
- Manhole steps shall be manufactured by MA Industries, Inc., Model No. PS2-PF (black) copolymer polypropylene plastic with grade 60 reinforcement or approved equal.
- Inverts and benches shall be extended completely with continuous slope across the base with a 0.20-foot minimum and 12-inch maximum drop across the manhole invert.

Coring and benching of pre-cast manhole bases may be completed in the field or at manufacturer's facility. The void area between the pre-cast invert, benches, and pipe shall be filled with concrete.

Bedding for manhole structures shall be per Section 4.12.5.

4.5.3. CAST-IN-PLACE CONCRETE BASES

Manhole base slabs for manholes constructed over existing sewer mains shall be poured-in-place on a minimum 6-inch thick bed of 3/4-inch to 1-1/2 inch crushed rock. The placed concrete shall extend a minimum of 8-inches below the pipe invert and the overall outside base dimensions shall be one (1) foot greater than the outside diameter of the manhole barrel sections.

The base shall be constructed of premixed concrete having a 28-day compressive strength of 4,000 psi, minimum. The concrete shall be composed of well-graded, well-washed, aggregate, ranging from sand to gravel 1-1/2 inches in maximum diameter.

The mix shall contain five (5) sacks of Type I/II cement to the cubic yard and only enough water shall be used in the mix to give it a slump test of two-inches (2"). Air entrained in the mix when placed, shall be between 3% and 5%. Base reinforcing steel or wire mesh shall be in accordance with the "Standard Manhole" detail found in Section 5 of these Specifications.

Sewer lines and manhole stub-outs shall be set before any concrete is placed and shall be rechecked for alignment and grade after the concrete pour, but before the concrete has set. All inlet and outlet pipes shall have installed on them an approved waterstop gasket prior to pouring concrete. Inlets and outlets to the manhole shall be located as indicated on the reviewed and signed Construction Plans.

All base deflectors shall be smooth and of the proper radius to provide a smooth flow transition in accordance with the "Base and Deflector" detail, found in Section 5 of these Specifications. The concrete base shall be shaped with concrete hand tools and shall receive a hard steel trowel finish before the concrete sets.

The accumulation of water on the surface of the concrete due to water gain, segregation, or other causes during placement and compacting, shall be prevented as much as possible. Provisions shall be made for the removal of such accumulated water. Under no circumstances shall new concrete be placed in standing water.

When concrete placement is performed during cold weather, the temperature of the concrete mix shall not be lower than 50° F. When concrete is placed during hot weather, the temperature of the concrete mix shall not be higher than 90° F.

For cast-in-place manholes constructed over existing mains, the upper half of the existing pipe shall be sawed out and the rough edges smoothed with cement mortar. Breaking out the top of the pipe is not permitted. No cutting of the pipe is permitted until after initial acceptance of the installations.

4.5.4. CONNECTIONS TO EXISTING MANHOLES

Sewer pipe connections to existing manholes where there is no existing pipe stubbed out shall be made in such a manner that the finished work will conform as nearly as practicable to the requirements specified for new manhole construction. The Contractor shall core drill a small opening in the existing manhole as necessary to insert the new sewer pipe. The core drill should extend through the manhole wall and into the channel. The core drill should not be "above the bench" so as to create additional fall through the manhole. The hole shall not be "broken out". The existing concrete foundation bench shall be chipped to the cross-section of the new pipe in order to form a smooth continuous invert similar to what would be formed in a new concrete base. Where practical, the downstream invert shall be plugged during construction to prevent construction debris, storm and non-sewage flow from entering the system. The Contractor shall pump out and clean the manhole before removing the plug. A non-shrink grout shall be used to smoothly finish the new invert and to seal the new line, both inside and outside, so the junction is watertight.

4.5.5. PRE-CAST BARREL SECTIONS

Pre-cast concrete barrel sections are to be used for all sanitary sewer construction and shall conform to ASTM C-478, Standard Specification for Precast Reinforced Concrete Manhole Sections. Barrel sections shall have tongue and groove joints.

Minimum wall thickness shall be as shown in Table 4.2:

Table 4.2 - Minimum Wall Thickness

Manhole I.D.	Wall Thickness
48"	5"
60"	6"
72"	7"

Reinforcement shall be Grade 60 and for circumferential placement shall consist of one line of steel in compliance with ASTM C-478 latest revision, and shall not be less than 0.12 square inches per linear foot in 48" I.D. manholes, and not less than 0.17 square inch per linear foot in manholes 60" I.D. and greater. Spacing of circumferential steel shall not exceed six (6) inches. All splices shall be welded or lapped not less than 40 diameters of wire.

Slabs shall be reinforced with two layers of steel with a minimum area of 0.12 square inch per linear foot in both directions in each layer. Openings in flat slabs shall be additionally reinforced with a minimum of the equivalent of 0.20 square inches of steel at 90°. Straight rods used to reinforce openings shall have a minimum length equal to the diameter of the opening plus two (2) inches. Covers shall be reinforced with two layers of steel with a minimum area of 0.12 square inches per linear foot in both directions in each layer.

Concrete curing for precast material shall take place in a steam curing chamber or other

moisture controlled environment for such time and at such temperature as may be needed to enable concrete to meet the minimum 4000 psi 28-day compressive strength requirement. Type II cement shall be used for all components.

4.5.6. MANHOLE JOINT CONNECTIONS

Each manhole section shall be placed in accordance with the manufacturer's recommendations in a plumb position. The eccentric cone and steps shall be centered between the inlet and outlet pipes. A two ring, single layer, of preformed flexible joint sealant (Kent Seal No. 2, Con-Seal CS-102 or CS-202, Henry RAM-NEK RN103 or District-approved equal) shall be used between each manhole section and shall be continuous around the entire manhole section circumference. All external joints shall be sealed with a 6-inch joint seam wrap (Conseal CS-212, Henry Rub'R Nek RU-116, or District-approved equal).

4.5.7. MANHOLE STAIRS

All manholes and vaults shall have stairs installed at 12-inches on-center from 12-inches below the top of the structure to 12-inches above the bottom.

Manhole stairs shall conform to the drawings found in Section 5 of these Specifications.

Stairs shall be steel reinforced polypropylene plastic coated steps and shall be driven into tapered holes. Manhole stairs shall be plastic steps manufactured by MA Industries, Inc., Model No. PS2-PF made from copolymer polypropylene plastic with grade 60 reinforcement, or District approved equal.

Whenever possible, holes for rungs shall be performed during the casting of the sections and shall not be drilled out after casting. The preformed holes shall be a minimum of 3-1/2 inches deep and shall taper from 1-1/8 inch to 1-3/8 inch diameter.

Under no circumstances shall manhole steps be used to lift manhole sections.

4.5.8. RING AND COVERS

Cast iron rings and covers shall conform to the drawings found in Section 5 of these Specifications. The castings shall conform to ASTM Designation A48, free from cracks, holes or swells. Ring and covers shall be Denver Light Pattern Cast Iron in areas of no vehicular traffic and Denver Heavy Pattern Cast Iron in streets and highways. All manholes located in easements, landscaped areas, or drainage ways shall be required to have aluminum rings and covers with bolt locking assembly. Aluminum castings shall conform to ASTM B26. All manhole covers used for sanitary sewer shall be furnished with the word "SEWER" cast on the cover. All manhole covers shall be cast with a "U-shaped" type pick-hole and not a wide, rectangular slotted pick hole.

Ring and covers shall be 24-inch in diameter for 48-inch and 60-inch I.D. manholes and two piece 36-inch by 24-inch for 72-inch I.D. manholes. Refer to appropriate ring and cover details for additional requirements.

Manhole rings and covers shall be set to the final grades shown on the plans. Manhole rings shall be securely attached to the manhole riser section with a grout bed and preformed joint sealing compound in pavement, or with a concrete collar in unpaved areas. After the rings

are securely set in place, covers shall be installed and the assembly shall be cleaned and scraped of foreign materials.

4.5.9. EXTERIOR COATING

All exterior surfaces of concrete manholes shall be completely coated with a water/damp-proofing agent. Exterior coating should be applied in the precast factory, prior to shipping. Acceptable manufacturers shall be as follows:

Bituminous
- Carboline – Bitumastic 300 M
- Tnemec - H.B. Tnemecol 46-465
- Or Approved Equal

Non-Bituminous
- C.I.M. Industries Inc. – CIM 1000 (Black)
- International Paint – Devtar 5A (Black)
- Or Approved Equal

4.5.10. INTERIOR LINING

Sanitary manholes shall receive interior linings in the following circumstances:

- All outfall manholes (sewer mains 12-inches and greater)
- All manholes or structures associated with force mains (private or public)
- All manholes at or near creeks, ditches, ponds, lakes, or known high ground water table
- All drop manholes
- Manholes as otherwise identified or directed by the District

Manhole interior linings shall meet the following minimum requirements:

1. Shall be a monolithic, 100% solids, solvent-free corrosion protection material with exceptionally high physical strengths and a broad range of chemical resistance.
2. Shall be specifically designed for application onto properly prepared concrete surfaces.
3. The coating shall be completely monolithic with uniform thickness, covering the entire interior of the manhole being lined, including but not limited to, barrel and cone section. There shall be no gaps, breaks, or seams within the structure including transition sections, or precast joints.
4. Coating on horizontal and vertical surfaces shall be not less than 250 mils and it shall be an integral part of the sewer manhole

Before application of top coating substrate surfaces shall be made smooth and uniform using a cementitious build-back product. Cementitious build-back shall be designed for highly corrosive sanitary sewer environments. Acceptable manufacturers are Strong-Seal® QSR, SewperCoat®, or District approved equal. All interior surfaces shall be prepped in accordance with the manufacturer's recommendations prior to lining.

Acceptable materials include:

- Raven® 405 by Raven Lining Systems.

- S-301 Epoxy Spray System by Warren Environmental, Inc.
- Spraywall® by Sprayroq
- District-approved equal

Installation of lining system shall be per the manufacturer's recommendations. Installation and application shall be by a licensed installer as certified by the manufacturer. Lining may be applied in the factory or in the field, however, factory linings shall be made monolithic in the field.

If product(s) come in various colors, the color shall be selected by the District.

4.5.11. FLAT TOP COVER

Generally, all top manhole sections shall be eccentric cone. Flat top covers shall only be used with written permission of the District. Flat covers shall be a minimum of eight (8) inches thick and designed to withstand a minimum H-20 traffic loading.

4.5.12. FINAL GRADE ADJUSTMENTS

Final grade adjustments shall be made using minimum four (4) inch pre-cast concrete grade rings not to exceed twelve (12) inches in total height. In open space areas, manhole rims shall be set four (4) inches above grade to prevent infiltration from surface runoff.

Brick courses and metal rings are not allowed for vertical adjustment. If the riser section exceeds the vertical limitation, the riser and eccentric cone section shall be removed and the appropriate sized barrel section added, followed by cone and grade ring replacement.

Slanted final grade adjustments, to account for street cross slopes, shall be made using brick chips and cement mortar.

4.5.13. MANHOLE TESTING

The Contractor shall submit the concrete mix design to the District for review at least 48 hours prior to any concrete base pour. The District may require that concrete cylinders be sampled from base pours and tested at 28 days to show conformance with the required 28-day compressive strength requirement of 4000 psi. Slump and air entrainment may also be tested during concrete base pour, at the District's discretion.

No other specific testing procedures are established for manholes. Manhole construction will be observed by the District and shall conform to the requirements of this Section.

4.6. SANITARY SEWER SERVICE CONNECTIONS

4.6.1. GENERAL

The purpose of this sanitary sewer service connection specification is to address the actual connection between the public sanitary sewer system and the private service line. The District is responsible for the sanitary sewer main line, manholes, and the wye fitting (also includes saddle when wye is installed on existing sewer main) on the main line for the sanitary sewer service, only.

All sanitary sewer services are private. This includes any and all service fittings and service pipe upstream of the wye fitting at the sewer main. Section of these Specifications describes the material requirements for fittings, branches and plugs.

4.6.2. SERVICE CONNECTIONS TO NEW CONSTRUCTION

New main line construction shall use PVC in-line "wye" fittings for four (4) inch and six (6) inch service connections, or manholes for eight (8) inch service connections. Construction shall be in conformance with this Section and the "Service Connections to New Construction" construction detail found in Section 5 of these Specifications.

All in-line PVC wye fittings shall be of equal pipe class to the PVC materials used in public main line construction. Fitting material shop drawings shall be submitted to the District for review prior to construction.

In-line wye fittings shall be installed at the locations indicated on the reviewed and signed plans. The "wye" shall be rotated to provide entrance into the main line at the "ten" or "two" o'clock position. The Contractor shall record the connection invert elevation and distance from the nearest downstream manhole immediately upon installation. This information shall be shown on the record drawings.

4.6.3. SERVICE CONNECTIONS TO EXISTING CONSTRUCTION

Service connections to existing sanitary sewer lines shall be made using a "wye" saddle. Construction shall be in conformance with this Section and the "Service Connections to Existing Construction" construction detail found in Section 5 of these Specifications.

Connection to existing PVC material shall be made using a "wye" saddle with double stainless steel straps. The existing PVC sewer line shall be scored to the shape of the wye using a template approved by the saddle manufacturer. The hole shall be cut with a hole cutter or keyhole saw and cleanly machined by hand to remove all burrs, rough edges, and debris. The exterior of the main shall be wiped clean and prepared with an approved solvent prior to the installation of the saddle. The saddle shall be solvent welded to the pipe and drawn tight against the pipe using double stainless steel straps.

Upon completion of the tap, the main line, tapping saddle and service line within the sanitary sewer line trench shall be bedded per Section 4.12.5 and hand tamped prior to backfilling.

Connection to existing concrete or clay sewer lines shall be made using a PVC wye saddle and gasket with double stainless steel straps. When connecting to an existing concrete or clay main, a long-body style PVC wye saddle shall be used. The sewer main shall be "core drilled" with a circular bit. Necessary precautions shall be taken so that the removed circular segment is not lost in the sanitary sewer main. Percussion taps shall not be allowed. A percussion tap is defined as breaking the existing pipe material out in a circular fashion using a hammer and chisel or similar method.

The circular hole shall be cleaned by hand to remove all rough edges and debris. The exterior of the main shall be wiped clean and prepared with an approved solvent prior to the installation of the gasket wye saddle. The saddle shall be drawn tight against the gasket and existing line by means of double stainless steel straps.

Upon completion of the tap; the tapping saddle shall be reinforced with a concrete collar. The main and tapping saddle shall be bedded with materials per Section 4.12.5 and hand tamped prior to backfilling.

4.6.4. SERVICE CONNECTIONS TO DEAD-END MANHOLES

Installation of a service connection 6-inch and smaller directly to a dead-end manhole shall be approved by the District on a case-by-case basis and may not follow an alignment "behind" a dead-end manhole.

4.6.5. TESTING OF SERVICE LINE CONNECTIONS

No specific testing is required for the in-line fittings or saddle type connections by the District. However, the Contractor shall notify the District 24 hours prior to making any service connections so the District may be on-site to observe the connection.

All service lines shall be plugged at the end of the service with a watertight plug manufactured for use with the service line material. End plugs must be able to withstand the internal pressure of leakage testing in accordance with Section 4.13 of these Specifications.

4.7. CLEANOUTS

Cleanouts are not permitted on Southgate Sanitation District lines. Cleanouts are recommended on private services at: any change in direction requiring horizontal or vertical bends, every 100 feet of service line, and at other locations as necessary for the Owner to clean the entire service by rodding.

Construction details showing material requirements and installation procedures for cleanouts are found in Section 5 of these Specifications.

4.8. STEEL CASINGS

4.8.1. GENERAL

Steel pipe shall be used for casing of sewer pipe in locations such as creek crossings, where jurisdictional authority or owner requires, or at critical locations as determined by the District. Steel casing pipe shall be installed to the limits shown on the Construction Plans. However, should field conditions differ from the information shown on the reviewed and signed plans, (e.g., ground elevations, creek locations), the casing pipe limits shall be reviewed in the field by the District, prior to any steel casing installation.

4.8.2. MATERIALS

4.8.2.1. PIPE

Steel casing shall be new, smooth wall, welded steel pipe fabricated from ASTM A36 plate or ASTM A570 and ASTM A139 (straight seam pipe only) Grade "B" with minimum yield strength of 36,000 psi. The casing pipe shall be designed by the pipe manufacturer with sufficient wall thickness to resist the loads applied.

External loading shall be AASHTO H20 highway or railroad loading plus jacking load, E-80 railroad loading. Casing pipes shall have the minimum nominal diameter and wall

thickness as shown in table below. Field and shop welds of the casing pipes shall conform to the American Welding Society (AWS) standard specifications. Field welds shall be complete penetration, single-bevel groove type joints. Welds shall be airtight and continuous over the entire circumference of the pipe and shall not increase the outside pipe diameter by more than 3/4-inch.

Minimum casing inside diameter shall exceed outside diameter of carrier pipe joints or couplings by an amount appropriate to allow the installation of the insulator band to be used. Casing size stated above is a minimum but shall generally be as shown in the Table 4.3 below.

Table 4.3 - Casing Pipe Minimal Nominal Diameter and Wall Thickness

Carrier Pipe Nominal Dia. (in)	Casing Nominal Diameter (in)	Min. Thickness for Coated Pipe (in)	Min. Thickness for Non-Coated Pipe (in)
8	18	0.250	0.312
10	20	0.281	0.344
12	24	0.312	0.375
16	30	0.406	0.469
18	30	0.406	0.469
20	36	0.469	0.531
24	42	0.500	0.563
30	48	0.563	0.625

4.8.2.2. CASING SPACERS

Casing spacers shall be 12-inch wide stainless steel, bolt on style type with a shell made of at least two halves. The bands shall be 14 gauge T304 stainless steel at a minimum, the risers shall be 10 gauge T304 stainless steel at a minimum, and the coating shall be fusion-bonded epoxy or heat fused PVC. Each spacer shall have a minimum of four runner supports manufactured of an ultra-high molecular with polyethylene or glass reinforced polymer. Bolts shall be T304 stainless steel with lock nuts. The runner supports shall be of adequate height to position the carrier pipe in the center of casing with a maximum clearance of 1-inch from the upper runner to the inside of the steel casing. Spacers shall be installed on the carrier pipe per the manufacturer's recommendations. Spacing of the casing spacers shall be per Section 4.8.4.1. Modifications to the casing spacers may be allowed on a case by case basis to maintain the correct grade of the carrier pipe. Acceptable manufacturers are as follows:

- Power Seal – Model 4810
- Cascade Waterworks – Model CCS
- Advance Products & Systems - Model SS1
- District Approved Equal

4.8.2.3. MODULAR WALL SEALS

Modular wall seals shall be adjustable modular mechanical type seals consisting of rubber bolted links with centering blocks and stainless steel bolts for adjustment. Wall seals shall be shaped to continuously fill the annular space between the casing and the carrier pipe so as to form a liquid tight seal. Construct so as to provide electrical isolation between the casing and the carrier pipe. Depending on the casing and carrier pipe annular space size, use of two modular seals stacked on top of each other, may be required to seal the annular space if approved by the modular seal manufacturer. Contractor shall coordinate with supplier at the time of ordering. Acceptable manufacturers are as follows:

- Link-Seal Modular Seals by GPT Industries
- District Approved Equal

4.8.2.4. END SEALS

Casing end seals shall be used to completely close both openings on either side of the casing water-tight. These ends seals shall be pull-on (seamless) or wrap-around with stainless steel straps for securing to the carrier pipe and the casing. End seals shall be constructed of specifically compounded synthetic rubber a minimum thickness of 1/8-inch. Acceptable manufacturers are as follows:

- Advance Products & Systems – Model AW
- PSI – Model C
- Power Seal
- District Approved Equal

4.8.3. CATHODIC PROTECTION

4.8.3.1. MATERIAL

For each continuous installation of steel casing one (1) anode shall be installed to provide cathodic protection. Anodes shall be high potential magnesium and meet the composition as shown in table 4.4 below.

Table 4.4 – Magnesium Anode Composition	
Aluminum (Al)	0.10% maximum
Manganese (Mn)	0.50 to 1.3%
Zinc (Zn)	0.005% maximum
Copper (Cu)	0.02% maximum
Nickel (Ni)	0.001% maximum
Iron (Fe)	0.03% maximum
Other Impurities – each	0.05% maximum
Total	0.30% maximum
Magnesium (Mg)	Balance

All anodes shall be furnished prepackaged in special backfill material consisting of 75% ground hydrated gypsum, 20% powdered bentonite and 5% anhydrous sodium sulfate. The backfill shall have a grain size such that 100% is capable of passing through a 20-mesh screen and 50% will be retained by a 100-mesh screen. The backfill mixture shall be firmly

packaged around the anode within a cotton bag by means of adequate vibration.

Anode lead wires shall be No. 12 AWG stranded copper conductors with Type RHW/RHH/USE black insulation. Lead wires shall be a minimum of 25 feet in length. The lead wires shall be connected to the galvanized steel core of the anode by silver soldering and sealed with waterproof epoxy or electrical potting compound.

The anode weight shall be 48 lb. bare (100 lb. packaged). Anodes shall be shipped in waterproof bags or wrapping and shall remain dry until installation. Anodes shall be Far West “MaxMag” high potential magnesium anodes or approved equal.

4.8.3.2. TEST STATIONS

Steel casing cathodic protection shall include flush-to-ground test stations consisting of test station enclosure, cast iron lid, terminal block with studs, and shunt. Flush-to-ground test stations shall be concrete valve box enclosures with an H20 traffic rating such as Christy Mfg. Model "G3" or "G5" with the lid inscribed with the words "CP TEST". Flush-to-ground test stations shall be furnished with an insulated terminal board made of fiberglass reinforced polyester laminate similar to that as manufactured by CP Test Services, Inc. (test station model NM-5 or NM-7 terminal board).

All splices of buried test station or anode wires shall be made using a copper split bolt type mechanical connector or a copper compression type connector, soldered using paste flux and resin core solder, and sealed with an epoxy type material. Splice kits shall be Royston Mini-Splice-Rite or equal.

4.8.3.3. WELDS AND COATINGS

All electrical cable connections to the buried piping shall be made by an exothermic weld. Exothermic type weld materials including the proper size and type of weld cartridges and welder molds for use on steel pipe shall be Erico Products Inc. "CADWELD" or Burndy THERMOWELD" or other approved equal. Weld materials shall be compatible to the pipe material as recommended by the Manufacturer. Copper sleeves specifically designed for the purpose shall be crimped on all bare wire ends prior to exothermic welding to improve mechanical strength and thermal capacity.

Exothermic weld coatings shall be Royston 747 Primer plus plastic weld caps prefilled with mastic. Royston Handy Caps are acceptable. Weld caps using an integrated primer such as Royston/Tapecoat Handicap IP may also be used. Coat entire primer area and plastic cap with wax tape, as specified.

4.8.4. INSTALLATION

Steel casing shall be installed in accordance with the "Steel Casing" construction detail, found in Section 5 of these Specifications. Minimum distance between end of steel casing and manhole structures shall be five (5) feet. Installation shall adhere to the same requirements for sewer pipe installation outlined in Section 4.12.

4.8.4.1. CASING SPACER

Furnish spacers for pipe alignment guides as indicated for all carrier pipe to be installed in casing:

1. Pipe skids shall be positioned on the pipe as shown on the drawings.
2. On both ends of casing place first casing insulator within 12 inches of the casing end.
3. On both ends of casing place second casing insulator within 12-inches of the first casing insulator (24 inches from the casing end).
4. Place third casing insulator within 5-feet of the second casing insulator.
5. Place remaining casing insulators at a spacing of :
   a. 10-feet for carrier pipes 10-inches or smaller
   b. 7.5-feet for carrier pipes 12-inches to 34-inches and
   c. 5.0 feet for carrier pipes 36-inches and larger
6. Place additional casing insulators for bell and spigot or mechanical joint piping 12-inches on each side of a joint.
7. Size to fit outside diameter of carrier pipe and inside diameter of casing pipe.
8. Insulators to be sized, at a minimum, slightly larger than carrier pipe's outside joint diameter.

4.8.4.2. MODULAR WALL SEALS

Construct modular wall seal as indicated and as follows:

1. After inside of casing has been thoroughly cleaned and approved by the District or its Representative.
2. After carrier pipe has been permanently placed inside casing. Pipe shall be centered and restrained, where called for in casing.
3. Place on both ends of the casing pipe.

4.8.4.3. END SEALS

Install end seal as indicated and as follows:

1. After inside of casing has been thoroughly cleaned and approved by the District or its Representative.
2. After carrier pipe has been permanently placed inside casing. Pipe shall be centered and restrained, where called for in casing.
3. Place on both ends of the casing pipe.

4.8.4.4. CATHODIC PROTECTION

Cathodic protection shall be installed in accordance with the "Cathodic Protection" construction detail, found in Section 5 of these Specifications.

Install galvanic anodes as follows:

1. All anodes shall be installed vertically or horizontally in native soils, a minimum of three feet laterally from the pipe to be protected and with the top of the anode below

the centerline of the pipe. However, anode spacing and lateral distance can be adjusted from permanent obstacles with the approval of the Owner's Representative.

2. The specified magnesium anodes shall be installed horizontally or vertically, completely dry and shall be lowered into the excavated (augured or otherwise) holes as shown on the Drawings by rope sling or by grasping the closest gather. The anode lead wire shall not be used in lowering the anodes. The anode shall be backfilled with fine native excavated soil (imported sand or other select backfill shall not be allowed) in 6-inch layers and each layer shall be hand tamped around the anode. Care must be exercised not strike the anode or lead wire with the tamper. After the anode has been backfilled approximately halfway, a minimum of ten gallons of fresh water shall be added and allowed to soak into and around the anode. After water absorption by the anode and surrounding soil, continue backfilling and tamping with native soil to a point approximately 6-inches above the anode. Add another 5 gallons minimum of fresh water and allow it to soak into the soil. After water has soaked in, backfilling and soil compaction may be completed to the top of the hole.

Perform exothermic welding as follows:

1. Exothermic welding techniques shall comply with the manufacturer's recommendations. Only properly sized cartridges and welders will be permissible. The Contractor shall ensure that the appropriate weld metal charges are used for each type of material.
2. The surface of the pipe shall be cleaned with a grinder or metal file to a bright, shiny condition. The exothermic weld shall be completed using the proper weld charge and welder as per the manufacturer's recommendations. A properly size copper wire sleeve shall be installed around the bare wire end prior to welding to improve weld strength and thermal capacity. Completed welds shall withstand moderate hammer blows.
3. After cooling, the weld and surrounding cleaned metal surface shall be primed. After the primer has dried, the weld shall be covered with an exothermic weld cap. The weld cap shall then be secured to the pipe with tape wrap as necessary.

4.9. CONCRETE ENCASEMENTS

4.9.1. GENERAL

Reinforced concrete encasement shall be constructed to the limits shown on the Construction Plans. However, should field conditions differ from the information shown on the reviewed and signed plans, (e.g., ground elevations, creek locations), the encasement limits shall be reviewed in the field by the District, prior to any encasement construction. Reinforced concrete encasement shall only be approved for use in special circumstances and shall require District approval prior to construction.

4.9.2. MATERIALS

Encasements shall be constructed of concrete made from well-graded aggregate and Type II cement, having a minimum twenty-eight (28) day compressive strength of 4000 psi, slump of 2"-4", and air entrainment of 3% to 5%.

Reinforcement steel used in encasements shall be ASTM A36 steel.

4.9.3. INSTALLATION

Reinforced concrete encasement shall be installed in accordance with the "Concrete Encasement" construction detail, found in Section 5 of these Specifications. Minimum clear distance between steel reinforcement and the edge of the concrete encasement shall be three inches. The encasement shall be formed using undisturbed soils or concrete formwork. Concrete shall be vibrated around steel reinforcement using vibration equipment or manual poling and shall not be placed on a frozen or unstable foundation. Suitable concrete protection shall be provided to reduce rapid moisture loss and to protect the concrete from freezing.

4.9.4. TESTING

The Contractor shall submit the concrete mix design to the District for review at least 48 hours prior to encasement construction. The District may require that concrete cylinders be sampled on-site and tested at twenty-eight (28) days to show conformance with the required twenty-eight (28) day compressive strength requirement of 4000 psi. Slump and air entrainment may also be tested at the time of concrete pour, at the District's discretion.

4.10. MARKER POSTS

Marker posts are required adjacent to manholes or other appurtenances installed outside of paved rights-of-way in order to provide a physical reference for field location.

Steel marker posts shall be four inch (4”) diameter steel posts, painted yellow, and filled with concrete.

Redwood marker posts shall be 4-inch by 4-inch (4"x4") and may also be used, at the Owner's discretion.

The appurtenance description, size, type, and distance from the post shall be stenciled (steel post) or routed (wood post) directly on the marker post.

Marker posts shall be installed at the locations indicated on the reviewed and signed plans and at other locations requested by the District during construction. Marker post installation shall be performed in accordance with the details, found in Section 5 of these Specifications.

4.11. CUT OFF WALLS

Cut off walls shall be constructed of Controlled Low Strength Material (CLSM) as specified in Section 4.12.7.3. Install double wrap of polyethylene wrap around all pipe in contact with CLSM cutoff wall.

4.12. SANITARY SEWER TRENCHING & BEDDING

4.12.1. EXCAVATION

4.12.1.1. GENERAL

Excavation for sanitary sewer lines, manholes, fittings and other appurtenances shall be an open trench excavation to the depth required by the reviewed and signed Construction Plans.

All excavations shall be properly supported in the manner as required by OSHA Code of Federal Regulations, Part 1926 "Safety and Health Regulations for Construction", Subpart P "Excavations", Standard Number 1926.652 "Requirements for protective systems", and the related sections, or as required by State laws and municipal ordinances, and as may be necessary to protect life, property and the work.

4.12.1.2. LIMITS OF EXCAVATION

Length - Except by expressed written permission of the District, the maximum length of open trench shall be 600 feet or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is smaller. The distance is the collective length at any location, including open excavation, pipe laying, appurtenances, construction, and backfill. The trench shall not be left open when the Contractor has left the project site and is not engaged in construction operations, unless temporary fences or barricades are provided. Additional controls such as steel plating shall be placed by the Contractor as required by the City, County, or State, or as stipulated by local conditions, to ensure construction safety at all times.

Width - Trench width at the ground surface may vary with and depend upon the depth, type of soils, and position of surface structures. In general, the minimum clear width of the trench, sheeted or un-sheeted, measured at the top of the pipe should be one (1) foot greater than the outside diameter of the pipe. The maximum clear width of the trench at the top of the pipe should not exceed a width equal to the outside pipe diameter plus two (2) feet.

If the above defined trench widths must be exceeded, or if the pipe is installed in a compacted embankment, the pipe embankment shall be compacted to 95% Standard Proctor Density, to a point at least 2.5 (two and one-half) pipe diameters from both sides of the pipe or to the undisturbed trench walls, whichever is less.

4.12.1.3. TRENCHING BY HAND OR MACHINE

Hand methods for excavation shall be employed in locations directed by the District. The Contractor shall use whatever equipment or hand methods necessary to protect all existing utilities.

4.12.1.4. BRACING EXCAVATIONS

All excavations shall be properly supported in the manner as required by OSHA Code of Federal Registrations Part 1926, Sub-part P, Section 1926.652 and other related sections or as required by state laws and municipal ordinances, and as may be necessary to protect life, property and the work. Excavations shall be so braced, sheeted and supported that they will be safe, and the ground alongside the excavation will not slide or settle. Excavations shall be so braced or sheeted so as to provide conditions under which workmen may work safely and efficiently at all times. The sheeting, shoring and bracing shall be so arranged as to not place any stress on portions of the completed work until the general construction thereof has proceeded far enough to provide ample strength.

Care shall be exercised in the withdrawing or removing of sheeting, shoring, bracing and timbering to prevent the caving in or collapsing of the excavation faces which are being supported.

4.12.1.5. ROCK EXCAVATION

Solid rock, boulders, and large stones shall be removed to provide a minimum clearance of at least nine (9) inches below the pipe and fittings.

In general, blasting will be allowed in order to expedite the work if a permit by the local authority having jurisdiction is granted. All explosives and appurtenances shall be transported, handled, stored and used in accordance with the laws of the local, state and federal governments, as applicable.

All blasting shall be controlled so as not to injure any existing structure or facility. Owners or occupants of nearby structures or facilities must be notified at least 72 hours in advance of blasting, in writing, by the Contractor. The notice shall state the anticipated date and time of blasting, and entity responsible for performing the blasting.

Blasting shall be controlled so as not to make any excavation unduly large or irregular as to shatter the rock on the bottom or sides of any excavation or surface upon or against which concrete is to be placed. If, in the opinion of the District, blasting could cause damage to rock foundations, supports, or structures, blasting shall not be allowed, and excavation shall be continued by jack-hammering, barring, wedging or other methods.

4.12.2. TUNNELING AND BORING

Tunneling or boring may be required by the City, State or County Highway Department where construction crosses major roadways. Boring and casing materials and construction methods shall be reviewed by the District on a case-by-case basis but will generally conform to the requirements outlined in Section 4.8 and on the "Pipe Casing" detail found in Section 5 of these specifications.

4.12.3. GRADING AND STOCKPILING

The Contractor shall control stockpiling and grading in such a manner to prevent water from flowing into excavations. Obstruction of surface drainage shall be avoided and means shall be provided to allow storm water to flow uninterrupted into existing gutters, other surface drains or temporary drains. Excavated material shall not be placed or stockpiled closer than two feet (2') from the top edge of the trench.

4.12.4. FOUNDATIONS AND SUBGRADE

4.12.4.1. GENERAL

All manholes or vault foundations and pipe subgrade installation shall be in a stable condition. Any and all questions relative to foundation and subgrade stability shall be coordinated through the District and the owner's Geotechnical Engineer. The Geotechnical Engineer will be responsible for determining if the foundation and/or subgrade are stable prior to the utility installation.

4.12.4.2. STABLE FOUNDATIONS AND SUBGRADE

The trench bottom shall be excavated six (6) inches below the invert of the pipe and structures unless otherwise designated on the plans. Before the pipe is laid, the foundation shall be prepared by backfilling with bedding material conforming to these Specifications.

4.12.4.3. DEWATERING

No sanitary sewer installations shall be made in the presence of groundwater.

The Contractor shall provide and maintain at all times during construction, ample means and devices with which to promptly remove and properly dispose of all water from any source entering the excavations or other parts of the work. Dewatering shall be accomplished by methods which will ensure a dry excavation and preservation of the final lines and grades at the bottoms of excavations. These methods may include well points, sump pumps, suitable rock or gravel drains placed below the bedding, temporary pipelines and other means, all of which shall be subject to the review of the District.

Dewatering of the sewer line trenches shall commence when groundwater is first encountered, and shall be continuous until such time that, in the opinion of the Owner's Geotechnical Engineer, it is safe to allow the water table to rise. Pipe trenches shall contain sufficient backfill to prevent pipe flotation.

The Contractor shall dispose of the water from the work site in accordance with federal, state, and local requirements, including but not limited to Colorado Department of Public Health and Environment, without damage to adjacent property or endangering public health or safety. Water shall not be drained into the sanitary sewer system.

4.12.4.4. FOUNDATIONS IN UNSTABLE SOIL

When excessively wet, soft, spongy, unstable or similarly unsuitable materials is encountered at the surface upon which the bedding material or foundations are to be placed, dewatering shall be performed and unsuitable materials shall be removed to a depth as determined in the field by the Owner's Geotechnical Engineer and the District.

The degree of soil instability will determine the limits of over excavation. In general, over excavation will be required, and stabilization rock shall be installed as indicated on the "Special Bedding" construction detail until the foundation and/or subgrade is stable as determined by the Owner's Geotechnical Engineer and the District.

4.12.4.5. OVERDEPTH EXCAVATION

Where excavation is inadvertently or otherwise carried below subgrade and/or foundation elevations, suitable provision shall be made to adjust the deeper excavation beneath pipe or structures. Over-depth backfilling, with bedding material or on-site material, shall be compacted to provide a firm and unyielding foundation, as directed by the Owner's Geotechnical Engineer and the District.

4.12.4.6. FOUNDATIONS IN ROCK

Where rock is encountered, it shall be removed below grade. The trench shall be backfilled

with clean imported bedding material to provide a compacted foundation cushion. The minimum clearance between rock and the pipe shall be nine (9) inches.

4.12.5. BEDDING

4.12.5.1. GENERAL

Unless specified otherwise on the Drawings or elsewhere in the Contract Documents, or directed otherwise by the District, the Contractor shall bed all pipelines according to these Specifications. If, in the course of construction, it is determined that the pipe foundation is unsatisfactory or the prescribed maximum allowable trench width is exceeded, the District may require that an alternative class of bedding be installed. The Contractor shall be required to place the improved bedding class or make other remedies, at their expense.

All pipe bedding materials for stable and unstable installation conditions shall be reviewed by the owner's Geotechnical Engineer and the District, prior to delivery of the bedding to the construction site. The area indicated in the bedding details from the trench bottom to twelve (12) inches above the pipe shall be referred to as the "pipe zone". Bedding materials and installation shall meet or exceed the requirements of this section.

4.12.5.2. BEDDING MATERIAL

Shall conform to ASTM C-33 or ASTM D-448, gradation size #67 Bedding as shown in Table 4.5.

Table 4.5 - Class 67 Gradation

Nominal Size	% Passing by Wt
1"	100%
3/4"	90-100%
3/8"	20-55%
No. 4	0-10%
No. 8	0-5%

This bedding shall consist of a durable crushed granular material with a well graded mineral aggregate mixture, which will provide good stability. Pipe bedding shall not contain recycled or manufactured materials. The size range of the aggregate shall be from 3/4-inch maximum with the amount of fines passing a No. 8 sieve not to exceed 5% by weight. At least 50% of the material greater than the 3/8-inch sieve shall contain particles having 3 or more fractured faces.

Substitutions of recycled materials or manufactured materials in place of mineral aggregate mixtures for pipe bedding will not be allowed.

4.12.5.3. SPECIAL BEDDING MATERIAL

Special bedding material shall only be used where required within the Contract Documents or requested within the project scope. All such bedding materials must be submitted and separately approved for use by the District. Recycled or manufactured materials will not be considered and alternate bedding materials used on site which have not been approved shall be rejected and the removal and replacement of these materials will be at the

Contractor's expense.

4.12.5.4. BEDDING INSTALLATION

The pipe shall be bedded as indicated in the "Standard Bedding" and "Special Bedding" details, found in Section 5 of these Specifications. The Contractor shall be responsible for accurately shaping the pipe subgrade to fit the bottom of the pipe. The intent is to relieve the bell of the pipe from all loading and provide continuous bearing of the pipe barrel on the bedding. Use of a drag template shaped to conform to the outer surface of the pipe will be required if other methods do not give satisfactory results.

The pipe shall be centered in the trench, adjusted to line and grade and bedding shall be simultaneously placed on both sides of the pipe as not to disturb alignment and grade. The bedding material shall be rodded, sliced, and cut under the haunches of the pipe to fill all voids. The rodding, slicing, and cutting shall be performed when the bedding material covers approximately one-third (1/3) of the pipe's diameter.

4.12.5.5. BEDDING COMPACTION

Initial bedding layer shall be laid in a uniform, level manner and compacted (i.e. hand tamping, "cutting and rodding", vibratory mechanism) as needed to achieve suitable compaction. Successive 6-inch lifts shall be laid and compacted in the same manner up to 12-inches above the top of pipe. Each lift shall be solidly compacted with the proper tools so as not to injure, damage or disturb the pipe. Backfilling shall proceed simultaneously on each side of the pipe. All bedding material shall be compacted to a minimum Relative Density of seventy percent (70%) as determined by ASTM D4253. Compaction tests for bedding may be required at the discretion of the District. Water settling for compaction is generally not permitted and must be reviewed by the District prior to its use.

4.12.5.6. BEDDING TESTING REQUIREMENTS

All bedding shall meet the gradation set forth in this Section. Bedding material shall be tested by the Owner's Geotechnical Engineer for gradation requirements, and test reports shall be submitted to the District, prior to delivery of and bedding material to the project site.

Bedding compaction may be required to be tested using the methods set forth in ASTM D4253 or other methods reviewed by the District. Compaction test results shall be submitted to the District on the working day following the test. If compaction tests do not meet these Specifications, the sub-standard area shall be reworked and retested until these Specifications are met. The location and frequency of bedding compaction testing will be determined by the District on a case-by-case basis.

4.12.6. SANITARY SEWER LINE INSTALLATION

4.12.6.1. GENERAL

Pipe shall be laid without grade break from structure to structure, with the bell ends of the pipe upgrade. Pipe shall be laid to the lines and grades shown on the reviewed and signed construction plans and shall form a close concentric joint with the adjoining pipe. The interior of the sewer pipe shall be cleaned of all dirt and superfluous material of all

descriptions, as the work progresses.

When pipe laying is not in progress, the open end of the pipe shall be closed with a tight fitting cap or plug to prevent the entrance of foreign matter into the pipe. These provisions shall apply during the noon/lunch hour, and breaks, as well as overnight and on holidays. In no event shall sanitary sewers be used as drains for removing water which has infiltrated into the trench.

A water-tight plug (Pollard, or equal), shall be installed at the point of connection to the existing system at the start of construction, and shall not be removed without permission of the District.

4.12.6.2. MATERIAL REVIEW BEFORE INSTALLATION

All pipe and fittings shall be carefully examined for cracks and other defects before installation. Spigot ends of pipe shall be examined with particular care as this area is the most vulnerable to damage from handling. Defective materials shall be set aside for review by the District. Provisions of Section 3.4 of these Specifications also apply.

4.12.6.3. LAYING OF SANITARY SEWER PIPE

Placement of PVC sanitary sewer pipe in the trench shall conform to ASTM D2321 Specification for "Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications" and these Specifications. Insofar as possible, commence laying at downstream end of line and install pipe with bell ends in direction of laying. Deviations from this will require approval from the District. Under no circumstances shall any sewer pipe be dropped or dumped into the trench.

Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the line. If the pipe laying crew cannot put the pipe into the trench and place it without getting earth into it, the District may require that before lowering the pipe into the trench, a heavy, tightly woven canvas bag of suitable size, or plastic caps, shall be placed over each end of the pipe and left there until the connection is made to the adjacent pipe. During laying operations, no debris, tools, clothing or other materials shall be placed inside the pipe.

As each length of pipe is placed in the trench, the spigot end shall be centered in the bell or coupling and the pipe forced home and brought to correct line and grade. The pipe shall be secured in place with bedding material. Precautions shall be taken to prevent dirt from entering the joint space.

4.12.6.4. ALIGNMENT AND GRADE

The sewer line shall be laid and maintained to the required lines and grades as shown on the plans.

Where obstructions or field conditions are encountered during construction which interfere to such an extent that an alternation in the reviewed plans is required, the District shall have the authority to change the plans in accordance with Section 3.8 of these Specifications.

Laser beam equipment shall be used to provide line and grade.

4.12.6.5. JOINT INSTALLATION

When manufacturer's prefabricated joints are used in the laying of sanitary sewer lines, such lines shall be jointed using lubricants, primers, adhesives, solvents, etc., recommended by the pipe manufacturer. All factory fabricated joints shall be placed, fitted, joined and adjusted in such a manner as to obtain the degree of water tightness required and be in compliance with recommended methods of manufacturer, and as accepted by the District.

4.12.6.6. FITTINGS AND BRANCH INSTALLATIONS

Pipe "wyes," shall be furnished and installed along with the sanitary sewer line. Wyes of the size(s) specified on the reviewed plans shall be installed for all sanitary sewer service connections as shown on the reviewed and signed construction plans. The longitudinal barrel or branch fittings to be placed in line and grade with the sanitary sewer mains shall be of the same diameter, quality and type as the adjoining sewer line.

Installation, earthwork and bedding for branches shall conform to the applicable provisions set forth for the sewer line. Unless otherwise specified, the branch of "wye" fittings shall be inclined upward at an angle not greater than 45° from a horizontal line. No wye for a sanitary sewer service connection branch may be placed closer than 5 feet, to the downstream edge of any structure, or three (3) feet from the bell or spigot end of a pipe section, and shall be in conformance with the "Service Connection to New Construction" detail. The Contractor shall hand tamp the backfill under every "wye" branch after it is installed.

All joints for plugs shall be installed in order to withstand the internal pressure of the leakage and/or infiltration test; however, joints shall be made in such a manner that they may be removed without injury to the socket.

4.12.6.7. PIPE AT MANHOLES OR STRUCTURES

A pipe joint of the same inside diameter as the adjoining pipe shall be placed at the inlet(s) and/or outlet to each manhole or structure as shown on the reviewed and signed plans.

Pipe bells shall not be cast into manholes or structures. The bell shall be cut off so that the plain end of the pipe is flush with the inside wall of the manhole or structure, or as otherwise shown on the accepted Construction Plans.

Subsequent to placing the pipe through the boot/gasket, the Contractor shall place a 1-inch thick bead of butyl resin concrete sealant or equal between the pipe and the core hole.

4.12.6.8. SANITARY SEWER LINE TESTING AND ACCEPTANCE

(See Section 4.13)

4.12.7. BACKFILLING

4.12.7.1. GENERAL

All trenches shall be backfilled after pipe, fittings and appurtenances have been installed and reviewed. When a compaction requirement value is specified herein, the optimum moisture content and density shall be determined in accordance with the appropriate ASTM specification.

4.12.7.2. BACKFILL MATERIAL

Backfilling shall be done with on-site material, sand or gravel. No oil cake, bituminous pavement, concrete, rock or other lumpy material shall be used in the backfill unless these materials are scattered and do not exceed 3" in any dimension. Material or perishable, organic, spongy, frozen debris, or otherwise unacceptable nature shall not be used in backfilling. No material greater than 3" in any dimension shall be placed within 1 foot of any pipe, manhole or structure. Backfill material shall be subject to the review of the District.

Within the street right-of-way, the road subgrade and final grade, including base course and asphalt placement, shall be replaced in strict accordance with the appropriate City, State or County Highway Department's Standards.

4.12.7.3. CONTROLLED LOW STRENGTH MATERIAL (CLSM)

Low strength flowable fill with a 28-day compressive strength not less than 50 psi or more than 200 psi as determined in accordance with ASTM D4832. CLSM should have a design slump between 6 and 10 inches when tested in accordance with ASTM C142. Slumps of less than 6-inches will not be permitted for placement, since the flowability to avoid settlement is impaired, and strengths may increase. CLSM backfill shall be of the removable type:

Removability of backfill shall have a Removability Modulus (RM) of 1.0 or less. Removability Modulus, RM, is calculated as follows:

$$RM = (W^{1.5} \times 104 \times C^{0.5})/10000000$$

W = unit weight of cured (dry) sample (pcf)
C = 28-day compressive strength (psi)

All CLSM (flow-fill and flash-fill) shall meet the following requirements for mix design:

Flow-fill:

1. Flow-fill is a self-leveling concrete material composed of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment.
2. Flow-fill shall have a slump of 7 to 10 inches, when tested in accordance with ASTM C143 or a minimum flow consistency of 6 inches when tested in accordance with ASTM D6103.
3. Flow-Fill shall have a minimum compressive strength of 50 psi at 28 days, when tested in accordance with ASTM D4832.
4. Flow-Fill shall be a thoroughly mixed combination of the following ingredients:

CLSM – Flow-fill	
Components	**lbs/CY**
Cement	50
Coarse Aggregate	1700 (AASHTO No. 57 or 67)
Fine Aggregate	1845 (AASHTO M6)
Water	325 (or as needed)

5. The amount of water shall be such that the Flowfill material flows into place properly without excessive segregation.
6. Approximately 39 gallons of water per cubic yard of flow-fill is normally needed
7. Alternative aggregate which does not meet the above specifications may be used if the cement is increased to 100 pounds per cubic yard and the aggregate conforms to the following gradation:

Alternative Aggregate	
Sieve Size	**% Passing**
1 inch	100%
No. 200	0-10%

8. A substitution of 30 pounds per cubic yard of cement and 30 pounds per cubic yard of fly ash may be used for 50 pounds per cubic yard of cement
9. A substitution of 60 pounds per cubic yard of cement and 60 pounds per cubic yard of fly ash may be used for 100 pounds per cubic yard of cement.
10. Sulfate resistant cement shall be used in areas prone to sulfate attack.

Flashfill (cementious fly ash):

1. Shall consist of a controlled low-strength, self-leveling cementious material composed of various combinations of cement, fly ash, water, chemical admixtures, and/or cellular foam for air-entrainment.
2. 28-day compressive strength not less than 100 psi or more than 200 psi as determined in accordance with ASTM D4832.
3. Flash-fill shall have a slump of 8 to 11 inches, when tested in accordance with ASTM C143 or a minimum flow consistency of 8 inches when tested in accordance with ASTM D6103.
4. Fly ash shall meet the requirements of ASTM C618 Type C or Type F.
5. Use only potable water or water clean and free of chemicals
6. Entrainments and Admixtures:
   a) Air-entraining admixtures shall conform to the requirements of ASTM C260.
   b) Foaming agents shall conform to the requirements of ASTM C869 and C796, or as otherwise approved by the engineer
7. Flash-fill shall be air entrained with a “foaming” cellular admixture which provides frost heave resistance and to improve removability.
8. Flowable fly ash backfill shall be a thoroughly mixed combination of the following ingredients:

CLSM – Flash-fill	
Components	**lbs/CY**
Class C Fly Ash	200 – 400
Class F Fly Ash	1600 – 1800
Water	800 (as needed for consistency)
Cellular air entrainment admixture (Foam)	As required to produce 15% air content or greater

Flash-fill shall be air entrained with a "foaming" cellular admixture which provides frost heave resistance and to improve removability. Flash-fill shall have an air content of 15% to 25%, when tested in accordance with ASTM C231.

The mix shall result in a product having a slump in the range of 8 to 11 inches, when tested in accordance with ASTM C142. Slumps of less than 7-inches will not be permitted for placement, since the flowability to avoid settlement is impaired, and strengths may increase.

4.12.7.4. BACKFILL INSTALLATION

In street rights-of-way the portion of the trench above the "pipe zone" to the finished roadway surface shall be backfilled, compacted and/or consolidated by methods reviewed by the District to obtain a Standard Proctor Density of 95% (ninety-five percent) or equivalent relative density. In easements and other areas outside street rights-of-ways, the remaining portion of the trench above the "pipe zone" shall be backfilled, compacted and/or consolidated by methods reviewed by the District to obtain a Standard Proctor Density of 90% (ninety percent) or equivalent relative density.

CLSM backfill may be used when required by the District or City/County. Generally, use of CLSM backfill over sewer installations should be avoided.

Backfill to be compacted by heavy compaction equipment shall be placed in uniform horizontal lifts not exceeding 15" in depth or as specified by the District. Heavy compaction equipment shall not be used closer than three feet to walls at the top of any structure nor closer than three feet to the top of the pipe. Before each lift is compacted, the material therein shall be brought within 1% above or 3% below the optimum moisture content for the specified compaction.

Flooding, pooling, or jetting shall not be allowed unless reviewed and accepted by the District, prior to construction.

Any damage to the pipe as a result of the Contractor's backfill and compaction operation shall be repaired and/or replaced by the Contractor.

4.12.7.5. BACKFILL COMPACTION TEST

Compaction tests shall be taken by a qualified testing laboratory at locations designated by the District. All expenses involved in these tests shall be borne by the Contractor or Developer.

Copies of test results shall be provided to the District. In all cases where the tests indicate

sub-standard compaction, additional compaction effort and tests will be required until these Specifications are met. Final acceptance of the lines by the District will be contingent upon satisfactory compaction results. Leakage and deflection testing of the sewer main shall not be performed until backfill compaction conforms to these Specifications.

4.12.7.6. CLSM STRENGTH SAMPLES

The Owner will be responsible, through services of an independent laboratory, to test all placed CLSM to determine conformance with specified material properties. CLSM shall be tested prior to placement in accordance with ASTM D5971. Testing shall include test for air content in accordance with ASTM C231, unit weight in accordance with ASTM D6023, and slump in accordance with ASTM C143 or flow consistency according to ASTM D6103. Determine unconfined compressive strength using cylinders of CLSM sampled, handled, cured, and tested in accordance with ASTM D4832. Perform a minimum of one set of four cylinders for every 50 cubic yards of CLSM placed but not less than one set for each day's placement, unless otherwise directed by District. If required the bearing strength shall be determined using penetration testing in accordance with ASTM C403.If required test flow of CLSM in accordance with ASTM C939.

4.12.8. FINAL CLEAN UP

Prior to probationary acceptance, the Contractor shall clean street right-of-ways and easements of all rubbish, excess materials, temporary structures and equipment and shall leave the same areas to plus or minus 1/10 of a foot from the elevations that existed prior to construction or the final grades as shown on the reviewed and signed plans.

4.13. SANITARY SEWER LINE TESTING AND ACCEPTANCE

4.13.1. VISUAL REVIEW PRIOR TO INSTALLATION

The following imperfections in any type of pipe or special fitting will be considered defects and cause rejection.

- Any cracks, lumps, blisters, pits or flakes on any interior or exterior surface of a pipe or fittings.
- When the pipe varies from a true circle more by than 3% of its internal diameter.
- When a pipe or fitting, designated to be straight, deviates from a straight line more than 1/16" per linear foot. The deviation shall be measured using a straight edge at a point midway between the ends of the pipe.
- When a piece is broken from either the socket or spigot end.

4.13.2. FLUSHING

Prior to any testing, the lines may be required to be hydraulically cleaned at a water pressure of not less than 1000 psi to remove debris, dirt or other foreign matter. The most downstream manhole (or manholes) within the project shall be plugged with a water-tight plug (Pollard or equal) on the downstream outlet of the manhole and all water, silt and debris shall be pumped from this manhole and disposed of properly.

4.13.3. ALIGNMENT AND GRADE TESTING

After the sewer line and all appurtenances have been installed and flushed, and satisfactory compaction test results have been submitted to the District, but prior to paving, the line shall be visually reviewed by the District for alignment and grade.

100% of all new sewer installations are required to be completely videoed using CCTV. Sags, high points or other alignment or grade problems shall be repaired by the Contractor to the District's satisfaction.

4.13.4. TELEVISION INSPECTION

After completion of the pipe installation, service connections, flushing and cleaning, the sewer line shall be televised with a color closed-circuit television (CCTV) with tilt-head camera. The CCTV video of the sanitary sewer shall include at a minimum the upstream and downstream manhole number, segment footage, location footage, date, project name, operator name, pipe diameter and material, surface condition (i.e asphalt, roadway, undeveloped easement), and weather conditions. CCTV video shall be in a recorded to a DVD or thumb drive and submitted to the District for review. Video format shall be NAASCO/PACP 4.2 compatible with Granite XP or IT Pipes.

4.13.5. LOW PRESSURE AIR TESTING

Each section of sanitary sewer line between manholes shall be low pressure air tested in accordance with UNI-BELL UNI-B-6 and ASTM F1417, Latest Revision and as specified herein.

4.13.5.1. PLUGS

All outlets from the pipe section being tested shall be plugged and braced to prevent plug blow-out during the pressure test. Either mechanical or pneumatic plugs may be used.

4.13.5.2. PRESSURING EQUIPMENT

All pressurizing equipment used in pressure testing shall include a regulator or relief valve set no higher than 9.0 psi to prevent over-pressurizing the line and to prevent plug displacement.

The above ground air control equipment shall include a shut-off valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0.0 to at least 10.0 psi. The continuous monitor gauge shall be at least 4-inches in diameter, with a minimum division of 0.10 psi and an accuracy of + 0.04 psi.

Two separate hoses shall be used. One to connect the control panel to the sealed line for introduction of low pressure air, and another separate hose connection for measurement of air pressure buildup in the line.

4.13.5.3. LINE PRESSURIZING

Low pressure air shall be slowly introduced into the sealed line until the air pressure reaches a value of 4.0 psi.

If the line being tested is in a groundwater condition, the internal air pressure value of 4.0 psi shall be increased to include the addition of groundwater pressure on the pipe.

The additional pressure shall be calculated by adding 0.433 psi internal air pressure for each foot of water over the sealed pipes invert, but the maximum allowable internal air pressure in the pipe shall not exceed 9.0 psi. Therefore, the low pressure air test may be used in a groundwater condition as long as the average depth of water over the line does not exceed 11.5 feet. Should the average groundwater depth exceed 11.5 feet, the infiltration test shall be performed in accordance with Section 0 of these Specifications.

4.13.5.4. PRESSURE STABILIZATION

After a constant pressure of 4.0 psi, (or 4.0 psi greater than groundwater back pressure over the pipe) is reached, the air supply shall be throttled to maintain the 4.0 psi air pressure for two (2) minutes. This allows the temperature of the air to equalize with the temperature of the pipe.

4.13.5.5. TIMED PRESSURE LOSS

After pressure stabilization, the air hose from the air supply shall be disconnected or shut off. The continuously monitoring pressure gauge shall be observed while the pressure is decreased to 3.5 psi (or 3.5 psi greater than the back pressure of any groundwater over the pipe). At that time, timing shall commence using a stopwatch, and the time interval measured until the internal pressure reaches 3.0 psi (or 3.0 psi greater than the back pressure of any groundwater over the pipe).

4.13.5.6. PASSING TEST REQUIREMENTS

If the timed pressure loss is greater than the minimum time outlined in the following tables, the segment undergoing the test shall pass. If the minimum time in Tables 4.5 & 4.6 is not met, the air loss is considered excessive and the test fails.

TABLE 4.6 – MINIMUM TIME FOR A 1.0 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE FOR Q = 0.0015

Note 1: Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 in. diameter.

Pipe Dia., in.	Min. Time, min:s	Length for Min. Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s							
				100 ft	*150 ft*	*200 ft*	*250 ft*	*300 ft*	*350 ft*	*400 ft*	*450 ft*
4	3:46	597	0.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	0.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:40	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	25:30	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366 L	28:20	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852 L	31:10	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768 L	34:00	76:55	102:34	128:12	153:50	179:29	205:07	230:46

TABLE 4.7 – MINIMUM TIME FOR A 0.5 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE FOR Q = 0.0015

Note 1: Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 in. diameter.

Pipe Dia. (in)	Min. Time, min:s	Length for Min. Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s						
				100 ft	*150 ft*	*200 ft*	*250 ft*	*300 ft*	*350 ft*	*400 ft*
4	1:53	597	0.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	0.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51
8	3:47	298	0.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38

Line Repair or Replacement - If the section being tested fails, the Contractor may be required to video the sewer line to determine the location of the defective area. The defective pipe shall be repaired or replaced and the low pressure air test performed until the test requirements are satisfied.

4.13.6. PIPE DEFLECTION TESTING

All sanitary sewer systems constructed of PVC pipe shall be tested for vertical ring deflection using a properly sized "Go, No-Go" Mandrel, or sewer ball. Maximum allowable vertical ring deflection shall be 5% of the pipe mean internal diameter. Tables 4.8 and 4.9 indicate minimum mandrel diameters for testing. Pipe shall be tested after backfill and compaction. Mandrel shall be suitable for the pipe type installed and maximum allowed deflection specified. Any pipe not meeting deflection limits shall be removed and replaced.

Table 4.8 – 5% Deflection Mandrel Dimensions for SDR35 PVC Sewer Pipe

Nominal Size (in)	Nominal ID (in)	Mandrel Size (in)
8	7.920	7.524
10	9.900	9.405
12	11.780	11.191
15	14.426	13.705
18	17.629	16.748

Table 4.9 – 5% Deflection Mandrel Dimensions for C900/905 PVC Sewer Pipe

Nominal Size (in)	Nominal ID (in)	Mandrel Size (in)
8	7.98	7.581
10	9.79	9.301
12	11.65	11.068
16	15.35	14.583
18	17.20	16.340

4.13.7. INFILTRATION TESTING

Where specified by the District, infiltration testing shall be performed instead of low pressure air testing. This generally would occur when a severe groundwater condition is present. The allowable infiltration for any portion of the sanitary sewer system shall not exceed 50 gallons per inch of inside pipe diameter per mile, per day (50 Gal/in-dia/mi/day), including manholes. The amount of infiltration shall be measured using a pipe weir, flume or other method proposed by the District. Groundwater pumping or dewatering shall not occur adjacent to lines being tested for a period of at least three days prior to the infiltration test.

The following Table 4.10 outlines the allowable units of infiltration for various sizes of pipe.

Table 4.10 – Allowable Limits of Infiltration

Sewer Diameter (in)	Infiltration (Gal/hr/100-ft)
8	0.32
10	0.40
12	0.48
15	0.60
18	0.72
21	0.84
24	0.96

Note: (50 Gal/in-dia/mi/day = 0.04 Gal/in-dia/100-ft/hr)

4.13.8. INTERIOR COATING TESTING

After the protective lining has set hard to the touch it shall be inspected with high-voltage holiday testing equipment. All detected holidays shall be marked and repaired by abrading the coating surface with grit disc paper or other hand tooling method. After abrading and cleaning, additional protective coating material can be applied to the repair area. All touch-up procedures shall follow the protective coating manufacturer's recommendation. A final visual inspection will also be required and may require a manufacturer's representative if determined by the District. The District also reserves the right to request a bond strength test.

4.13.9. CONVEYANCE AND ACCEPTANCE

Conditional and final acceptance by the District of facilities intended to be owned and operated by the District shall be accomplished as provided in Article 6 of the Rules and Regulations.

4.13.10. FINAL TESTING

Approximately 11 months after the start of the Warranty Period, the District will perform a final inspection and provide Owner/Contractor a final punch-list identifying any items in need of repair or replacement. The District will review 100% of the installed line segments by CCTV video inspection for grade variations, separated pipes, leaks, deflection, debris, cracked, broken or otherwise defective pipe to ensure overall pipe integrity.