ITEM II - SANITARY SEWER PIPE, FITTINGS, & ACCESSORIES

2.01 General

(a) All sanitary sewers 15 inches in size and smaller shall be constructed of either vitrified clay, ductile iron or PVC sewer pipe as shown on the Plans. All sanitary sewers 18 inches, 21 inches, and 24 inches in size shall be constructed of either vitrified clay, ductile iron or concrete sewer pipe, or unless otherwise shown on the Plans. All sanitary sewers larger than 24 inches in size shall be constructed of precast concrete sewer pipe, ductile iron pipe or centrifugally cast fiberglass pipe, unless otherwise shown on the Plans.

(b) All vitrified clay, concrete, PVC, and ductile iron sewer pipe and fittings shall be suitably marked at their places of manufacture to show their class, strength, or thickness, as applicable.

(c) All materials used in the manufacturer of sewer pipe and fittings used on the DISTRICT's systems and projects shall be certified by the manufacturer to meet or exceed ASTM, AWWA, NSF and other nationwide accepted standards for the appropriate type of pipe or fittings. Each joint of pipe delivered to the job site shall be stamped or otherwise marked to indicate the testing laboratory's acceptance or approval. In addition, if required by the ENGINEER, all pipe and materials shall be inspected, tested and certified by an accredited commercial testing laboratory, approved by the ENGINEER, prior to or after delivery of such pipe and/or materials to the job site and shall be certified to meet or exceed the requirements set forth in these specifications. Certified copies of all testing and acceptance reports shall be delivered, in duplicate, to the ENGINEER prior to the use of such materials on the project. The cost of any inspecting and/or testing shall be borne by the CONTRACTOR or pipe manufacturer. Laboratory testing of other materials may be required if deemed necessary by the ENGINEER.

(d) All materials and products used on projects funded by the DISTRICT and/or projects constructed with non-DISTRICT funds which are to be accepted for maintenance and operation by the DISTRICT shall be **"Made in the U.S.A"** unless otherwise approved by the ENGINEER. This requirement shall include all raw materials, processing, manufacture, and fabrication. To ensure conformance to this requirement, the country of origin shall be legibly and permanently affixed by die stamping, molding or etching in a visible location on the final product. The country of origin marking shall appear on the top surface of all manhole covers, frames, or rings. If the name of any city or locality in the U.S. appears on the product, the name of the country of origin shall be preceded by "Made in" or "Product of" or words to that effect. This phrase must be of comparable size as the name of the city or locality and placed as close as reasonably possible thereto. In addition, on any project funded in part or whole by Federal or State funds, all materials and products used on that project shall comply with the provisions of the Federal Intermodal Surface

Transportation Act of 1991 and regardless of any DISTRICT approvals of shop drawings and/or materials specifications, the CONTRACTOR shall be fully and completely responsible for conformance to the provisions of this Act.

2.02 Vitrified Clay Pipe

(a) Vitrified clay sewer pipe and fittings shall be "extra strength" and shall conform to the requirements of ASTM Specification C 700-07. The pipe bedding and loading shall comply with MSD standard details. Bedding shall be as shown on the trench details, Plans or in Special Conditions. Pipe and fittings 18 inches in diameter and smaller shall have plain ends and shall be joined by plastic sleeve couplings or shall have bell and spigot ends joined with rubber ring gaskets. Pipe and fittings 21 inches in diameter and larger shall have bell and spigot ends joined with rubber ring gaskets or factory applied resilient joint material. All jointing material shall comply with the requirements of ASTM Specification C 425. Couplings for clay pipe to clay, PVC, and ductile iron pipe shall be as manufactured by Maxadaptor or equal.

2.03 Concrete Pipe

(a) Concrete sewer pipe shall be centrifugally cast, horizontally cast on a vibrating table, or vertically cast and vibrated. The pipe class, bedding, and loading shall comply with MSD standard details. The pipe shall be as shown on the Plans, or as required by the trench details. Bedding shall be as shown on the trench details. Wall thicknesses shall be "Wall B" in diameters 33 inches in diameter and smaller and "Wall C" in diameters 36 inches and larger. Concrete sewer pipe shall be tested under and shall comply with the requirements of ASTM Specification C 76, except as modified herein. All concrete sewer pipe shall have bell and spigot joints suitable for installation with rubber O-ring gaskets and with a rectangular groove in the spigot end to receive the rubber gasket and contain the deformed gasket on all four sides when the joint is completed. Concrete pipe shall be cast in lengths of not less than 8 feet long for 18-inch and 21-inch diameters and not less than 12 feet long for 24-inch and larger pipe diameters. Bell and spigots shall be formed to true dimensions, with a nominal clearance of not more than 1/16 inch. Concrete used in the manufacture of pipe shall have a 28-day compressive strength of not less than 6,000 pounds per square inch, and the absorption shall not exceed 6 percent. Steel reinforcement shall be circular. Materials used in the manufacture of concrete sewer pipe shall comply with the following ASTM Specifications: Portland Cement C 150, Type II or C 175, Type IIA, or C 205 for Blast Furnace Slag Cement; Aggregates, C 33 except that the fine aggregate shall be natural silica sand. Manufactured sand shall not be used.

(b) Coarse aggregates shall be crushed limestone. Joints and gaskets shall comply with AWWA Specification C 302. Each joint of pipe shall have stamped thereon the class of reinforcement and the wall thickness designation. Couplings for concrete pipe to concrete pipe or ductile iron pipe shall be submitted to the ENGINEER for approval, prior to use.

2.04 PVC Pipe

(a) Poly-Vinyl Chloride (PVC) sewer pipe and fittings shall conform to the requirements of ASTM Specification D 3034. Wall thickness shall be SDR 35. Joints shall be integral bell and spigot type with compression type rubber gaskets. Joints shall conform to ASTM Specification D 3212. Couplings for PVC pipe to PVC pipe shall be PVC "Closure" or "Stop" couplings and shall meet ASTM D 3034. Transition Couplings for PVC pipe to ductile iron pipe shall be mechanical joint ductile iron fittings utilizing transition gaskets. No more than one material transition will be allowed in any one reach of pipe.

2.05 Ductile Iron Pipe

(a) Ductile iron pipe shall conform to the requirements of ANSI Specification A21.51. The pipe class, bedding, and loading shall comply with MSD standard details. When loading conditions are beyond those shown, the ENGINEER will submit design computations to the DISTRICT. The pipe class shall be as shown on the Plans. Bedding shall be as shown on the trench details. Joints shall be "push-on" which conform to the requirements of ANSI Specification A21.11. Ductile iron fittings shall conform to the requirements of ANSI Specification A21.10, Class 350 in sizes 24 inches and smaller and Class 250 in sizes larger than 24 inches, unless otherwise shown on the Plans. All ductile iron pipe shall have a cement mortar lining of standard thickness conforming to the requirements of ANSI Specification A21.4.

(b) All fittings for ductile iron pipe, including but not limited to wyes, tees, saddles, bends, crosses, sleeves, plugs, caps, reducers, and glands, shall be gasketed push-joint pipe or mechanical joint. Fittings shall conform to the requirements of ANSI/AWWA C110/A21.10 (Standard fittings, 3 inches thru 48 inches) or ANSI/AWWA C153/A21.53 (Compact fittings, 3 inches thru 48 inches) with the joints meeting the requirements of ANSI/AWWA C111/A21.11 (Rubber-gasket joints) and shall be pressure rated at the same rating as the mainline sewer pipe but in no case less than 250 psi. Gasketed push-joint type fittings shall meet or exceed the requirements as set forth in ANSI/AWWA C 111/A 21.11 and may be used only in non-pressurized in-line locations and below ground installations. Mechanical joint fittings shall meet or exceed the requirements as set forth in ANSI/AWWA C111/A21.11. All fittings shall be manufactured from ductile iron grade 70-50-05 (min. tensile strength – 70,000 psi; min. yield strength – 50,000 psi, min. elongation – 5%) as specified in AWWA C110 or C153 and ASTM A536. All ductile iron pipe fittings and materials shall conform to paragraph 2.01 (d) of this section of the Technical Specifications. All ductile iron pipe fittings shall have a cement mortar lining of standard thickness conforming to the requirements of ANSI Specification A21.4. Note: Couplings for ductile iron pipe to ductile iron pipe shall be ductile iron mechanical joint sleeves, only.

(c) All sanitary sewer cleanout boxes and covers shall be manufactured from gray iron

meeting the requirements of ASTM A48 or ductile iron grade meeting the requirements of AWWA C110 and ASTM A536. All sanitary sewer cleanout boxes and covers shall conform to paragraph 2.01 (d) of this section of the Technical Specifications. All sanitary sewer cleanout boxes shall conform to the dimensions and requirements as set forth in MSD's Standard Detail for Cleanout Boxes (MSD-12) and shall be U.S. Foundry Handhole Ring and FC Cover model #7610 or East Jordan Iron Works Heavy Duty Monument Box model #1574 or approved equal. Note: U.S. Foundry Handhole Ring and FC Cover model #7630 may be used where cleanout box is within an asphalt or concrete paved area.

2.06 Centrifugally Cast Fiberglass Pipe

(a) Centrifugally Cast Fiberglass Reinforced Plastic (FRP) pipe shall meet the requirements of ASTM D3262 - Standard Specification for Reinforced Plastic Mortar Sewer Pipe, ASTM D3681 - Method for Determining Chemical Resistance of Reinforced Thermosetting Resin Pipe in Deflected Condition, and ASTM D4161 - Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin Pipe Joints) using flexible elastomeric seals.

(b) Submittals shall provide sufficient data for the ENGINEER to properly evaluate the pipe. Product data shall include the following, as a minimum:

1. Details for the proposed pipe.
2. Properties and strengths of the pipe.
3. Details of joint.
4. Pipe design analysis (including trench details).
5. Instructions for storage, handling, transporting and installation.
6. Standard catalog sheets.

Test reports shall be provided, certifying that the pipe has been tested in accordance with, and meets or exceeds minimum requirements of ASTM 3262 and ASTM D3681.

2.07 Wyes, Saddles, and Services

(a) Wyes and Saddles shall be of the same material and strength as the sewer mains on which they are installed, unless otherwise specified. Saddle type fittings shall not be used on new construction or existing mains for pipes 12 inches in diameter or smaller, unless specifically called for in the Plans and/or Specifications or approved in writing by the ENGINEER. For ductile iron mains greater than 12 inches in diameter, "CB" Romac tapping saddles as manufactured by Romac Industries Inc. or an approved equal may be used. Unless otherwise specified in the Plans and/or Specifications, house services shall be constructed of 4-inch diameter Schedule 40 PVC pipe or Class 350 psi ductile iron pipe.

(b) For taps and services on an existing MSD maintained PVC or VCP sewer main (6

inches in diameter) that are being repaired by trenchless construction methods, flexible saddles as manufactured by NDS/HPI or an approved equal may be utilized. Flexible Saddles shall be affixed to the Main by bands or straps as provided by the manufacturers and by using a two-part epoxy glue uniformly spread over the contact surface of the saddle.

(c) A compression coupling by Inserta-Tee or approved equal shall be used to re-connect services to existing 8-inch and larger diameter sewer mains that are being rehabilitated by trenchless construction methods.

(d) Wyes shall be placed in sanitary sewers so as to properly serve each existing house and each vacant lot facing or butting on the street or alley in which the sewer is being laid, and at such other locations as may be designated by the ENGINEER.

(e) The CONTRACTOR shall measure the distance to the tap or tee from the downstream manhole and the offset distance to each cleanout assembly to obtain the information required for the "As-Built" records. As-built data shall be marked on the Plans and turned over to the ENGINEER at the end of the project.

(f) The location of all wyes, cleanouts, and house sewers installed in the work shall be identified on the Plans and in the field.

2.08 Pipe Laying

(a) Before sewer pipe is placed in position in the trench the bottom and sides of the trench shall be carefully prepared and the necessary bracing and sheeting installed. Each pipe shall be accurately placed to the exact line and grade called for on the Plans.

(b) Each piece of pipe and special fitting shall be carefully inspected before it is placed and no defective pipe shall be laid in the trench. Pipe laying shall proceed upgrade, starting at the lower end of the grade and with the bells upgrade. Pipe shall be straight when placed in the trench. Curved pipe shall not be laid. Trench bottoms found to be at incorrect grade after pipe laying operations has begun shall be corrected and brought to exact line and grade. Any fill required to bring the trench bottom to grade, shall be pipe foundation material or pipe embedment material as specified herein, as applicable.

(c) Bell holes shall be of sufficient size to allow ample room for properly making the pipe joints. The bottom of the trench between bell holes shall be carefully graded so that the pipe barrel will rest on a solid foundation for its entire length.

(d) Each joint shall be laid so that it will form a close concentric joint with adjoining pipe and so as to avoid sudden offsets or inequalities in the flow lines. The inside of all bells and the outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter. Joint lubricants shall be compatible with the pipe and gasket

materials and shall be as recommended by the pipe manufacturer.

(e) All jointing of pipe and fittings shall be in accordance with the pipe manufacturer's recommendations.

(f) Any leaks or defects discovered at any time shall be repaired immediately. All pipe in place shall be carefully protected from damage until the backfilling operations have been completed. Any pipe which has been disturbed shall be taken up, the joint cleaned and remade, and the pipe re-laid at CONTRACTOR's expense.

(g) Water shall not be allowed to run or stand in the trench while pipe laying is in progress or before the joints are completed or before the trench has been backfilled. The CONTRACTOR shall not open up at any time more trench than his available pumping facilities are able to dewater.

(h) As the work progresses, the interior of all pipe in place shall be thoroughly cleaned. After each line of pipe has been laid it shall be carefully inspected and all dirt, trash, rags, and other foreign matter removed from the interior. When pipe laying is not in progress, the CONTRACTOR shall place a watertight plug in the last section of pipe which has been laid. The CONTRACTOR shall install temporary watertight plugs in the proposed sewer line at any manhole that is incomplete, at the open end of the pipeline prior to leaving the job site daily and elsewhere as dictated by good engineering and construction practices. All installed pipe shall be backfilled to prevent flotation in the event water enters or rises in the trench. The plugs as installed shall prevent infiltration or the introduction of any foreign material into either the existing or proposed systems. Upon completion of all construction, the CONTRACTOR will be responsible for the complete removal of all watertight plugs.

(i) Backfilling of trenches shall be started immediately after the pipe is in place and the joints completed.

2.09 Deflection Tests

(a) After backfilling trenches, all sewer pipes shall be lamped and visually inspected for pipe alignment. Each run of pipe must present a full circle of light when viewed from one of the connected manholes. Any run of pipe which does not present a full circle of light will be removed and reinstalled.

(b) After backfilling trenches, all PVC sewer pipe shall be tested for initial diametric deflections by the use of a Go-No-Go type mandrel which is acceptable to the ENGINEER. The initial diametric deflection shall not exceed five percent of the base inside diameter as defined in ASTM D-3034. Deflection tests will be performed after trench is no longer subject to construction traffic loading and a minimum of 30 days after completion of trench backfill.

Nominal Pipe Size	**Pipe I.D. (SDR 35)**	**Required Mandrel O.D.**
8"	7.665"	7.28"
10"	9.563"	9.08"
12"	11.361"	10.79"
15"	13.898"	13.20"

(c) The mandrel shall be pulled through each section of pipe from manhole to manhole. The mandrel must slide freely through the pipe with only a nominal hand force applied. No mechanical device shall be used in pulling the mandrel. Any pipe which refuses the mandrel shall be removed and replaced. Such sections shall be re-tested for deflection 30 days after completion of trench backfill.

(d) Mandrel testing may be performed by the DISTRICT at any time prior to the expiration of the one-year warranty. Any pipe which refuses the mandrel shall be replaced by the CONTRACTOR as described above.

2.10 Leakage and Infiltration

(a) All pipe and manhole joints shall be watertight. Any leaks into the sewer shall be repaired or corrected as directed by the ENGINEER. The DISTRICT reserves the right to TV any section of the sewer system to locate point sources of infiltration, either in the pipe or inside manholes. When directed by the ENGINEER, any desired section shall be isolated and tested separately.

(b) No sooner than 10 days following completion of backfill, the CONTRACTOR along with the ENGINEER, will be required to determine the level of the ground water table. If the ground water table is above the top of the pipe, the sewer line shall be tested for infiltration. If ground water table is less than 2 feet above the top of the pipe, the sewer line shall be low pressure air tested. Each test shall be performed as follows:

(1) **Infiltration**

The infiltration into each section of the sewer shall be measured in wet weather by the temporary installation of suitable metal or wooden weirs as authorized by the ENGINEER. These weirs shall be furnished, installed and removed by the CONTRACTOR. Infiltration test limits shall be applied to single reaches of pipe, up to one mile in length, of the same diameter. For pipes 8 inches through 15 inches in diameter, infiltration into the sewer system (including manholes) shall not exceed 50 gallons per mile of sewer per inch of inside diameter of the sewer per 24 hours, and in no case shall it exceed 3,000 gallons per mile per 24 hours. For all pipe sizes larger than 15 inches in diameter, infiltration into the sewer system (including manholes) shall not exceed 100 gallons per mile of sewer per inch of inside diameter of the sewer per 24 hours,

and in no case shall it exceed 3,000 gallons per mile per 24 hours.

(2) **Air Testing of Gravity Sewers**

The CONTRACTOR shall conduct low pressure air tests on all completed sections of gravity sewer. Air tests for PVC, DIP, and VCP lines will be performed in accordance with ASTM C828. Air tests for concrete pipe 30 inches in diameter and smaller shall be performed in accordance with ASTM C924. Air test results will be used to evaluate materials and construction methods on the sewer line sections, and successful air tests shall be mandatory for the acceptance of the sewers 30 inches in diameter and smaller.

(a) Air tests will not be required on pipe with diameters exceeding 30 inches. Acceptance of pipes exceeding 30 inches will be based on infiltration tests and/or visual inspection of the joints.

(b) The CONTRACTOR shall furnish an air compressor of the necessary capacity along with all necessary plugs, valves, pressure gages, air hoses, connections, and other equipment necessary to conduct the air tests. Plugs in sewers 18 inches in size and larger shall be connected by steel cable for thrust reaction.

(c) Compressor capacity shall be sufficient to pressurize the sewer main to 4 psig within a time equal to or less than the required test time. The following equation may be used to ensure compliance with this requirement:

$$C = \frac{0.17 \times D^2 \times L}{T} + Q$$

Where: C = Required Compressor Capacity (cfm)
T = Required Test Time (min) L = Length of Test Section (feet)
D = Pipe Internal Diameter (feet) Q = Allowable Air Loss Rate (cfm)

(d) The following allowable air loss rates will be used for all pipe tests:

Pipe Size	Q (cfm)	Pipe Size	Q (cfm)
4"	2.0	15"	4.0
6"	2.0	18"	5.0
8"	2.0	21"	5.5
10"	2.5	24"	6.0
12"	3.0		

(e) The sewer section shall be plugged at both ends and air pressure shall be applied until the pressure inside the pipe reaches 4 psig. When a stable condition has been reached, the pressure shall be bled back to 3.5 psig. At 3.5 psig, the time and pressure shall be observed and recorded.

If groundwater is present at the sewer, the height of groundwater above the top of the pipe shall be added to the above air pressure readings (height of water in feet X 0.433 = air pressure in psig). A minimum of 5 readings will be required for each test.

(f) If the time for the air pressure to decrease from 3.5 psig to 2.5 psig is equal to or greater than that shown in the following table, the pipe shall be presumed to be free from defects. When these times are not attained, pipe breakage, joint leakage, or leaking plugs are indicated and the cause must be determined and corrected. After repairs have been made, the sewer sections shall be retested. This process shall be repeated until all sewer sections pass the air test.

(SEE NEXT PAGE FOR PIPE TEST TIMES)

Minimum Test Times for Pipe

Pipe-Size →	4"	6"	8"	10"	12"	15"	18"	21"	24"
25	0:04	0:10	0:17	0:22	0:26	0:31	0:36	0:44	0:53
50	0:09	0:20	0:35	0:44	0:53	1:02	1:12	1:29	1:47
↑ **75**	0:13	0:30	0:53	1:06	1:20	1:34	1:48	2:14	2:40
100	0:17	0:40	1:11	1:29	1:47	2:05	2:24	2:58	3:33
L									
E 125	0:22	0:50	1:29	1:51	2:13	2:36	3:00	3:43	4:27
N 150	0:26	1:00	1:47	2:13	2:40	3:07	3:36	4:27	5:20
G 175	0:31	1:10	2:04	2:35	3:07	3:39	4:12	5:12	6:14
T 200	0:35	1:20	2:22	2:58	3:33	4:10	4:48	5:57	7:07
H									
225	0:40	1:30	2:40	3:20	4:00	4:41	5:24	6:41	8:00
O 250	0:44	1:40	2:58	3:42	4:27	5:13	6:00	7:26	8:54
F 275	0:49	1:50	3:16	4:05	4:53	5:44	6:36	8:10	9:47
300	0:53	2:00	3:33	4:27	5:20	6:15	7:12	8:55	10:41
P									
I 325	0:58	2:10	3:51	4:49	5:47	6:47	7:48	9:40	11:34
P 350	1:02	2:20	4:09	4:11	6:14	7:18	8:25	10:24	12:28
E 375	1:06	2:30	4:27	5:34	6:40	7:49	9:01	11:09	13:21
400	1:11	2:40	4:45	5:56	7:07	8:21	9:37	11:54	14:14
T									
E 425	1:15	2:50	5:02	6:18	7:34	8:52	10:13	12:38	15:08
S 450	1:20	3:00	5:20	6:40	8:00	9:23	10:49	13:23	16:01
T 475	1:24	3:10	5:38	7:03	8:27	9:54	11:25	14:07	16:55
E 500	1:29	3:20	5:56	7:25	8:54	10:26	12:01	14:52	17:48
D									
525	1:33	3:30	6:14	7:47	9:21	10:57	12:37	15:37	18:42
↓ **550**	1:38	3:40	6:31	8:09	9:47	11:28	13:13	16:21	19:35
575	1:42	3:50	6:49	8:32	10:14	11:60	13:49	17:06	20:28
600	1:47	4:00	7:07	8:54	10:41	12:31	14:25	17:51	21:22

(g) For testing a sewer system with one or more installed service lateral pipes, an effective pipe length shall be added to the total sewer main pipe length. The equation used to calculate Effective Pipe Length is as follows:

$$L_e = \frac{d^2 \times l}{D^2}$$

Where: Le = Effective Pipe Length (added to Total Test Length)
d = Diameter of Service Lateral Pipe (inches)
l = Length of Sewer Lateral (feet)
D = Diameter of Sewer Main Pipe being tested (inches)

2.11 Manholes

(a) General

(1) Manholes shall be constructed to the sizes, shapes and dimensions and at the locations shown on the plans. Unless otherwise shown on the Plans, manholes shall be as follows:

8" to 18" pipe ..… 4' diameter .... 5" thick walls
21" to 36" pipe ..……5' diameter .... 5" thick walls
39" to 54" pipe ..……6' diameter .... 6" thick walls
54" and larger ..……8' diameter .... 8" thick walls

(2) The height or depth of each manhole will vary with its location, but it shall be such as will place the top at the finished grade of the pavement or ground surface or to the elevations shown on the Plans and the invert at the elevation shown on the Plans. The number of joints shall be minimized. No more than one riser section for manholes up to six feet tall and no more than one riser for each additional 4 feet in height. One additional section will be allowed for transition manholes.

(b) Drop Manholes

Drop manholes shall be similar in construction to the standard manhole except that a drop connection of pipe and fittings of the proper size and material shall be constructed outside the manhole and supported as indicated on the Plans.

(c) Manhole Construction

(1) Manholes shall be composed of precast reinforced components with tongue and groove joints. Manholes shall conform to the requirements of ASTM Specification C478, except as modified herein.

(2) Concrete: Concrete shall conform to ASTM C478 and as follows:

Compressive strength:	5,000 psi minimum at 28 days.
Air Content:	5 - 7 %
Alkalinity:	Adequate to provide a Life Factor, Az = Calcium Carbonate Equivalent times Cover over Reinforcement, no less than 0.35 for bases, risers and cones.
Cementitious Materials:	Minimum of 564 pounds per cubic yard

Coarse Aggregates:	ASTM C33. Sound, crushed, angular granitic stone only. Smooth or rounded stone shall not be used. Free from organic impurities.
Chemical Admixtures: (if used)	ASTM C494. Calcium Chloride or admixtures containing calcium chloride shall not be used.

Air Entraining Admixtures (if used): ASTM C260.

Absorption shall not exceed 6 percent.

(3) Reinforcing: Reinforcing steel shall be ASTM A615 grade 60 deformed bar, ASTM A82 wire or ASTM A185 welded wire fabric.

(4) Lifting Loops: Lift loops shall be ASTM A416 steel strand. Lifting loops made from deformed bars shall not be used.

(5) Wall Thickness: The minimum wall thickness of the manhole riser sections shall be as shown in the table above. Cone sections shall have a minimum wall thickness of 8 inches at their top. The minimum thickness of the bottom shall be 6 inches for manholes 4 feet in diameter and 8 inches for all sizes greater than 4 feet in diameter. Suitable openings for inlet and outlet sewer pipe shall be cast or cored into the base sections and into riser sections for drop connections. These openings shall be circular, accurately made, and located as required for each manhole.

(d) Manhole Components

(1) Precast Manufacturing: Precast components shall be manufactured in conformance with ASTM C478. Wall and inside slab finishes resulting from casting against forms standard for the industry shall be acceptable. Exterior slab surfaces shall have a float finish. Small surface holes, normal color variations, normal form joint marks, and minor depressions, chips and spalls will be tolerated. Dimensional tolerances shall be those set forth in the appropriate references and specified below.

(2) Certification: Precast manufacturer shall manufacture all precast components with one or more of the following testing methods.

Plant shall be certified by the National Precast Concrete Association (NPCA) Plant certification program.

Plant shall be certified by the Prestressed Concrete Institutes (PCI) Plant certification program.

Manufacturing process of components delivered shall have been randomly tested by a DISTRICT-approved outside agency (such as a State Department

of Transportation) no less than 5 weeks prior to manufacture. Test results covering no less than one component in 100 and certification from cement manufacturer and aggregate supplier certifying chemical content will be furnished to the DISTRICT upon request. Minimum test shall cover concrete strength and absorption.

Components delivered shall be tested by a certified outside testing agency. Test results covering no less than one component in 25 and certification from cement manufacturer and aggregate supplier certifying chemical content will be furnished to the DISTRICT upon request. Minimum test shall cover concrete strength and absorption.

Precast concrete manholes shall not be shipped to the job site prior to 15 days after the date of manufacture.

Joints: Neither rubber gaskets nor O-Ring seals shall be used. The maximum slope of the vertical surface shall be 2 degrees. The maximum annular space at the base of the joint shall be 0.10 inch. The manhole sections shall be joined as specified herein.

Lift Inserts and Holes: If used for handling Precast Components, lift holes and inserts shall be sized for a precision fit with the lift devices, and shall comply with OSHA Standard 1926.704.

Step Holes: Step holes shall be cast or drilled in the bases, risers and cones to provide a uniform step spacing of 12 inches or 16 inches. Cast step holes shall be tapered to match the taper of the steps.

(3) Precast Base Sections: Base sections shall have the base slab cast monolithically with the walls, or have an approved PVC waterstop cast in the cold joint between the base slab and the walls. Where extended base manholes are required, the width of the base extensions shall be no less than the base slab thickness. The bottom step in the base section shall be a maximum of 16 inches from the top of the invert bench and shall be located directly over the outlet pipe.

(4) Precast Riser Sections: The minimum lay length of Precast Riser Sections shall be equal to the step spacing used by that manufacturer.

(5) Precast Concentric and Eccentric Cone Sections: Precast Cone Sections shall have an inside diameter at the top of no less than 24 inches and no more than 26 inches. The width of the top ledge shall be no less than 8 inches and no less than the wall thickness required for the cone section. Concentric cones shall be used only for shallow manholes.

(6) Precast Transition Cone Sections: Transition Cone Sections shall provide an

eccentric transition from 60 inch and larger manholes to 48-inch diameter risers, cones and flat slab top sections. The minimum slope angle for the cone wall shall be 45 degrees. A minimum of 6 feet height is required between the bench and the bottom of the transition cone.

(7) Precast Transition Top Sections: Transition Top Section shall provide an eccentric transition from 60 inch and larger manholes to 48-inch diameter risers, cones, and flat slab top sections. Transition Top sections shall be furnished with vents as shown on the manhole details. The maximum amount of fill over the transition top section shall be 20 feet. Transition tops shall not be used in areas subject to vehicle traffic. A minimum of 6 feet height is required between the bench and top of transition cone.

(8) Precast Flat Slab Top Sections: Standard Flat Slab Top Sections shall have an access opening with an inside diameter at the top of no less than 24 inches and no more than 26 inches and shall be designed for HS-20 traffic loadings as defined in ASTM C890. Items to be cast into Special Flat Slab Tops shall be sized to fit within the manhole ID and the top and bottom surfaces. Flat Slab Top Sections shall not be used without prior authorization from ENGINEER.

(9) Precast Grade Rings and Brick: Precast Grade Rings or Brick shall be used to adjust ring and covers to finished grade. No more than 12 vertical inches of grade rings or brick will be allowed per manhole. Grade Rings shall conform to ASTM C478 and shall be no less than 4 inches in height. All brick used shall be solid and shall be made from Concrete, Clay, or Shale, and shall be of standard building size.

(10) Steps: Provide steps in bases, risers, cones, transition cones, and transition top sections aligned vertically on 12-inch or 16-inch centers. All steps shall be aligned vertically over the outlet pipe. Secure steps to the wall with a compression fit in tapered holes. Steps shall not be vibrated or driven into freshly cast concrete. Steps shall not be grouted in place. The steps shall be a Copolymer Polypropylene Plastic reinforced with a ½ inch diameter grade 60 bar and have serrated tread and tall end lugs. Step pullout strength shall be a minimum of 2000 lbs. when tested according to ASTM C497. The minimum width shall be 12 inches. Rubber or plastic covered steel steps shall be as manufactured by Delta Pipe Products Co., M. A. Industries, Inc., or equal. All manhole steps shall comply with the requirements of OSHA.

(11) Lifting Devices: Lifting devices complying with OSHA Standard 1926.704 for handling the Precast Components shall be provided by the Precast Manufacturer.

(12) Coatings: Where shown on the Plans, the interior/exterior of the manhole walls shall be coated with 21 mils of Coal Tar Epoxy, Koppers 300M or equal. The coating shall be spray applied according to the manufacturer's recommendations by an applicator with a minimum of 5 year's experience. The joints between precast sections shall not be coated. Use butyl rubber rope as specified below to seal the interior horizontal joint surface.

(13) Joint Sealing Materials: Joints shall be sealed by **TWO** Butyl Rubber Seals. Each seal shall be as described below:

(a) Butyl Seals shall consist of a plastic or paper-backed butyl rubber rope no less than 1 inch cross section. When manholes are larger than 4 feet diameter or have a larger than normal space between the joints, the length and or diameter of the rope shall be increased as required to achieve a seal. Butyl Rubber Material shall conform to Federal Specification SS-S210A, AASHTO M-198, Type B - Butyl Rubber and as follows: maximum of 1% volatile matter and suitable for application temperatures between 10 and 100 degrees F. Butyl Rubber shall be applied to clean, dry surfaces only. Use of 2 independent wraps of Butyl Rubber qualifies for the requirement of two seals.

(b) Internal O-Ring Gaskets and Internal Rubber Gaskets shall not be used.

(e) Manhole Sleeves and Entrance Joints

Flexible manhole sleeves or flexible manhole entrance joints shall be installed on all pipe entering and leaving precast manholes. Manhole openings shall be accurately core drilled or cast in place. Sleeve and Joint material shall be of high quality synthetic rubber which complies with the requirements of ASTM Specification C 923. Sleeve hardware (clamps, bands, straps, draw bolts, nuts, etc.) shall be stainless steel and make a watertight union. Sleeves shall be Kor-N-Seal I, Kor-N-Seal II, flexible connectors models 72, 73, 74, 107, 117, 126, 127, 128, 1610, or 1612 as manufactured by EPCO, or shall be as manufactured by Lock Joint a subsidiary of Gifford-Hill-American, Inc. or comparable sleeves as manufactured by the Press Seal Gasket Corporation, or equal. Flexible manhole entrance joints may be cast into the wall of the manhole base or may be installed by coring the manhole wall and installing the flexible connector to form a tight waterstop. Joints shall be watertight under a 30 foot head of water. Flexible manhole entrance joints shall be A-LOK Joints as manufactured by the A-LOK Products Corp., Press Wedge II as manufactured by the Press Seal Gasket Corp., or equal. Flexible manhole sleeves and flexible manhole entrance joints shall be installed in accordance with instructions of their manufacturer. Alternative entrance joint connections must be approved by ENGINEER prior to construction.

(f) Placing Manhole Sections

The CONTRACTOR shall excavate to the required depth and remove materials that are unstable or unsuitable for a good foundation. Prepare a level, compacted foundation extending 6 inches or more beyond the manhole base.

The base shall be set plumb and level, aligning manhole invert with pipe invert.

Thoroughly clean bells and spigots to remove dirt and other foreign materials that may prevent sealing. Unroll the Butyl Sealant rope directly against base of spigot. Leave protective wrapper attached until sealant is entirely unrolled against spigot. Do not stretch. Overlap from side to side - not top to bottom.

Risers and cones shall be set so that steps align, taking particular care to clean, prepare and seal joints.

(g) Manhole Final Finishing

After placement of manhole frame and vacuum testing, perform the final finishing to the manhole interior by filling all chips or fractures greater than 1/2 inch in length, width or depth (1/8 inch deep in inverts) with non-shrink grout. Grout the interior joints between the precast concrete sections with non-shrink grout. Sharp edges or rough finishes shall be removed providing a smooth surface throughout the manhole. Clean the interior of the manhole, removing all dirt, spills, or other foreign matter.

(h) Connection to Existing Manholes

Any connection with 18 inches and smaller pipe at an existing precast or cast-in place manhole will require the CONTRACTOR to core the necessary opening through the manhole wall and install a flexible manhole to pipe connector. Connector shall be as specified elsewhere. Connections to existing brick manholes do not require coring and an opening may be carefully hammered or sawed. Connections to existing manholes with pipe larger than 18 inches may be cored or sawed as approved by the ENGINEER. Connection to an existing manhole may be made without using flexible pipe connectors only if approved by ENGINEER.

Whenever a connection is made without a flexible pipe connector, a concrete collar shall be poured in accordance with MSD standard details. The existing manhole bench and invert shall be repaired as specified under manhole materials and installation.

(i) Manhole Inverts

(1) Manhole inverts shall be constructed of brick and cement grout or precast concrete and shall have a "U" shaped cross section of the same diameter as the invert of the sewers which they connect. "U" shaped inverts shall be

constructed to a minimum depth of 6 inches for 8 inch sewers (unless full depth is required in Specifications or on the Plans) and to full pipe diameter depth of the outlet sewer main for larger mains. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections. Changes in direction of flow through the sewer, whether horizontal or vertical, shall be made with true tangent curve(s) with as large a radius as the size of the manhole will permit. Manhole benches shall slope a minimum of 2 inches to the lip of the "U" shaped invert. Provide a ½ inch radius at the intersection of 2 or more channels. The minimum concrete thickness in the invert of the channel shall be 2 inches, not including the manhole base thickness.

(2) When the invert is not constructed at the precast company, the CONTRACTOR shall construct the invert using 4000 psi concrete or non shrink grout. Non-shrink grout (minimum 2-inch thickness on invert channel and on bench) may be plastered over layered brick and mortar in lieu of solid non shrink grout invert.

(3) Inverts shall meet the following additional requirements:

Pipe Openings: Pipe openings shall provide clearance for pipe projecting a minimum of 2 inches inside the manhole. The crown of small I.D. pipe shall be no lower than the crown of the outlet pipe.

Trough: The fall across the manhole invert shall be as noted on the plans.

Bench: Finish benches to provide a uniform slope from the high point at the manhole wall to the low point at invert trough. Provide a radius (1/8 inch to 1 inch range is acceptable) at the edge of the bench and trough.

Gradual smooth sided depressions and high spots may be allowed so long as diameter of invert channel ranges from 1/4 inch less than, or 1/2 inch more than the nominal pipe diameter are maintained. Voids, chips, or fractures over 1/8 inch in diameter or depth shall be filled with a non-shrink grout and finished to a texture reasonably consistent with the bench surface. All work from collar down shall have a steel trowel finish.

(j) Manhole Frame and Cover Construction

(1) Manhole frames and covers shall be made of cast iron conforming to the minimum requirements of ASTM Specification A48, Class 35B. All castings shall be made accurately to the required dimensions and shall be sound, smooth, clean and free from blisters and other defects. Defective castings which have been plugged or otherwise treated shall be rejected. The contact surfaces between the cover and its corresponding supporting ring in the frame shall be machined so that the cover will rest on the ring for the full perimeter

of the contact surfaces.

(2) All frames and covers shall comply with AASHTO HS20 loading requirements. All manhole frames shall be standard height (7" for EJIW's 1045Z frame or 8" for USF 577 frame) unless a reduced height frame is specified in the project plans or specifically approved or required by the ENGINEER. All manhole frames shall be equipped to accept a cam-lock cover. However, only those frame and covers designated on the plans as "watertight" and/or "lock-down" shall have covers equipped with cam-locks. All manholes designated as "watertight" shall be "lock-down" and those designated "lock-down" shall be "watertight". When "lock-down" manholes are required, covers shall be furnished with two stainless steel, pentagon headed cam-locks, located and constructed as per the MSD details cited below. Frames and covers designated as "watertight" shall have a cover equipped with a one-piece gasket permanently attached in a groove in the bottom of the manhole cover. (See MSD Details 2.11-08.1 and 2.11-08.2). An ORS gasket shall be placed in a dove tailed groove in the bottom of the cover and the cam-lock feature shall provide sufficient pressure to prevent cover movement and subsequent wear of gasket.

(3) All covers shall have two 5/8-inch diameter lifting bars set into the cover to allow for lifting by a chain hoist. There shall be no holes or perforations in covers. Manhole covers shall be either standard covers or watertight / lock-down covers and shall meet the additional requirements set forth in paragraphs 6 or 7 below. Watertight /lock-down covers shall be required and used when specified in the project plans; when the diameter of the sewer main equals or exceeds 18 inches in diameter, where the manhole is subject to flooding, or when required by the ENGINEER. Shop drawings shall be sent to the ENGINEER for review and acceptance prior to manufacturing and shipping of castings to the job site.

(4) Pre-approved Heavy Duty Standard Frames include:

USF 577 Ring (with tooling for Bi-Loc Cover) as manufactured by U.S. Foundry & Mfg. Corp.

1045Z-1040AGS (with cam-lock ramp) as manufactured by East Jordan Iron Works, Inc.

(5) Pre-approved Reduced Height Frames include Model 1046Z1 (with cam-lock ramp) as manufactured by East Jordan Iron Works, Inc.

(6) Pre-approved Standard Logo Manhole Covers shall be:

USF IB-ORS as manufactured by U.S. Foundry and MFG. Corp as approved by MSD on November 25, 2009 or EJIW NPR 10-508D as manufactured by

East Jordan Iron Works and approved by MSD on March 17, 2010, or approved equal.

(7) Pre-approved Water-Tight Lock-Down Manhole Covers shall be:

USF IB-ORS-LOC manhole cover as manufactured by U.S. Foundry Corp. or EJIW NPR10-508B as manufactured by East Jordan Iron Work, Inc. or approved equal.

(8) Manhole Frame Placement

After the manhole has been set in its final position, set the manhole frames to the required elevation using no more than 12 inches of precast concrete grade rings, or bricks sealing all joints between cone, adjusting rings, and manhole frame. When grade rings or bricks are used, grout with cement mortar. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted so as to conform to the exact slope, crown and grade of the existing surrounding pavement. Manhole frames which are placed above final grade will have frames attached to manhole cone section by means of 5/8-inch diameter steel anchors and steel washers. One anchor bolt shall be provided per hole.

(k) Manhole Submittal Data

Drawings and descriptive data on manholes (including wall thicknesses, vertical dimensions, and deflection angles), concrete used in manufacture of manholes and precast inverts, rubber gaskets, joint sealant, flexible manhole sleeves and joints, frames and covers, inverts, and manhole steps shall be submitted to the ENGINEER for review prior to their manufacture.

(l) Manhole Delivery, Storage, and Handling

The CONTRACTOR shall coordinate delivery with the manufacturer, and shall handle and store the manhole components in accordance with the ASTM C891 and the manufacturer's recommendations using methods that will prevent damage to the components and their joint surfaces.

(m) Grouts

All grouts used on manhole interiors shall be "non-shrink" grouts, and grout used on manhole exteriors shall be either "non-shrink" or standard cement mortar grouts, as specified in Item III, Concrete Construction, of the Specifications.

2.12 Vacuum Testing of Manholes

(a) Vacuum testing of manholes shall be required on no less than 10 percent of the manholes installed. In addition, no less than 5 manholes will be tested. The DISTRICT will select which manholes shall be tested after construction. Vacuum testing each manhole prior to backfilling is recommended as most repairs must be made on the manhole exterior. Vacuum testing is not required on manholes with pipe connections in excess of 30 inches diameter. Vacuum testing shall be made at the CONTRACTOR'S expense. For extensions constructed by Developers and/or projects under the responsible charge and supervision of an Engineer other than DISTRICT's ENGINEER, the Engineer shall certify that the tests were done in accordance with the required testing procedures and that the test reports accurately depict the results of those tests.

(b) Vacuum test the assembled manhole after completing pipe connections, sealing and allowing mortar or cement proper curing time. The vacuum test shall be as follows:

(1) Plug pipes with suitably sized and rated pneumatic or mechanical pipeline plugs. Place plugs a minimum of 6 inches beyond the manhole wall and brace to prevent displacement of the plugs or pipes during testing.

(2) Position the vacuum tester head assembly according to the manufacturer's recommendations.

(3) Draw a vacuum of 10 inches of mercury, close the valve on the vacuum line and shut off the vacuum pump.

(4) Measure the time for the vacuum to drop to 9 inches of mercury. The manhole shall pass when the time to drop to 9 inches of mercury meets or exceeds the following:

Manhole I.D. (inches)	48	60	72	84	96	120
Time (seconds)	60	75	90	105	120	150

(5) If the manhole fails the test, remove the head assembly and coat the manhole interior with a soap and water solution and repeat the vacuum test for approximately 30 seconds. Leaking areas will have soapy bubbles. Make the necessary repairs and repeat the test until the manhole passes.

2.13 Existing Utilities and Separation Requirements

(a) The CONTRACTOR will be required to excavate to determine the precise location of utilities, or other underground obstructions, which are shown on the Plans and/or marked by the utility owners. Such location and excavation shall be at least 500 feet ahead of construction, unless otherwise noted.

(b) All utility owners shall be notified prior to excavation as required by the 1985

Underground Damage Prevention Act. Utility owners who are members of NC OneCall may be notified by calling 811(toll free) before any excavation or drilling. The CONTRACTOR will be fully responsible for damage to any utilities if the owners have not been properly notified as required by the Underground Damage Prevention Act. All damage to such structures and pipelines and all damage to property or persons resulting from damage to such structures and pipelines shall be borne by the CONTRACTOR and shall be completely repaired within a reasonable time. No claim shall be made against the DISTRICT for damage or delay of the work on account of the proximity of, or the leakage from, such structures and pipelines. Where high pressure gas lines are to be crossed, they shall be uncovered by hand excavation methods before other excavation near them is started.

(c) Utility owners may, at their option, have representatives present to supervise excavation in the vicinity of their utilities. The cost of such supervision, if any, shall be borne by the CONTRACTOR.

(d) Conflicts with underground utilities may necessitate changes in alignment and/or grade of this construction. All such changes will be approved by the ENGINEER before construction proceeds.

(e) When underground obstructions not shown on the Plans are encountered, the CONTRACTOR shall promptly report the conflict to the ENGINEER and shall not proceed with construction until the conflict is resolved.

(f) When a sewer main or lateral crosses an existing water main or other utility, the CONTRACTOR shall make the installation in accordance with the minimum specifications of the Controlling Agency and in accordance with the following minimum requirements. When a sewer main or lateral crosses or parallels an existing utility, the following clearance requirements are to be met or ferrous sewer pipe with watertight joints shall be used for a distance of 10 feet outside said point of crossing or until horizontal separation requirements are achieved.

(1) Min. Vertical Separation for Sewer Crossings:

Storm Sewers -	18" Vertical	
Under Water -	18" Vertical	
Over Water -	18" Vertical	* Sewer over water requires that both pipes shall be ferrous pipe with a 20 foot jointless span centered at crossing. *
Cable -	18" Vertical	
Power -	18" Vertical	
Gas -	18" Vertical	

(2) Horizontal Separations:

Storm Sewers -	5'
Water Mains -	10'
Water Supply -	100' (AS-I Waters, Class I or Class II impounded reservoirs)
Water Supply -	50' (WS-I, WS-II,WS-III, B, SA, or SB Waters – Natural High Water)
Designated Trout Streams -	25'
Other Stream, Lake or Impoundment -	10'
Building Foundation -	5'
Basement -	10'
Ground Water Lowering and Surface Drainage Ditch	10’
Swimming Pool -	10'
Private Wells -	25'
Public Wells -	50'

2.14 Boring and Jacking

(a) Steel Encasement pipe for Boring and Jacking shall be welded or seamless, consisting of Grade B steel as specified in ASTM A139. Encasement pipe and joints shall be leak proof construction, capable of withstanding dead loads and live loads specific to the site. Steel pipe shall have a minimum yield strength of 35,000 psi. The encasement pipe and method of boring shall meet the requirements of American Association of State Highway Transportation Officials (AASHTO) or the American Railway Engineering Association (AREA), as applicable.

(b) Spiral Weld or Smooth Wall Steel Encasement Pipe, may be jacked through dry bores slightly larger than the pipe, bored progressively ahead of the leading edge of the advancing pipe as spoil is mucked by the auger back through the pipe. As the dry boring operation progresses, each new section of encasement pipe shall be butt-welded to the section previously jacked into place. Continuous checks shall be made as to the elevation, grade and alignment of each successive section of encasement as well as the tracks (rails) upon which the boring rig travels.

(c) Bore Pits (or Tunnel Pits) shall be shored, as described under shoring and shielding herein, well marked, securely fenced, lighted, and not left unattended except as approved by the ENGINEER. Requirements for stabilization and dewatering of bore pits shall be as previously specified. The angle of repose method (sloping pit walls) for creating a safe working area shall not be used unless specifically approved by the ENGINEER.

(d) If voids are encountered or occur outside of encasement pipes, grout holes shall be installed in the top section of the encasement pipe at 10-foot centers and the voids filled with 1:3 Portland cement grout at sufficient pressure to prevent settlement in the roadway/railway.

(e) Boring operations shall be continuous to their completion, and unnecessary or prolonged stoppages shall not be allowed.

(f) In the event an obstruction is encountered during the boring or jacking operations, the auger is to be withdrawn and the excess pipe is to be cut off, capped, and filled with 1:3 Portland Cement Grout at sufficient pressure to fill all voids before reapplying to the Controlling Agency for a new bore site or permission to tunnel.

(g) Completed casing installations shall be such as to prevent the formation of a waterway under the road or railbed.

(h) The Controlling Agency shall have full authority to require remedial measures and/or to stop all work if, in its opinion, said work will cause any damage to the roadway/railway section or endanger traffic.

(i) The CONTRACTOR shall notify the Controlling Agency and the DISTRICT such that acknowledgement shall be received a minimum of 5 working days prior to beginning any work within roadway or railway rights-of-way. If required, 24-hours notice will be given prior to completion.

(j) Carrier pipes inside steel encasements shall be constructed of ductile iron pipe as specified on the Plans. The carrier pipe shall be centered in the encasement and be supported by spacers and runners ("spiders").

For encasement pipes 24 inches in diameter and less, the spacers and runners shall be at 10 feet on center and not more than 5 feet from each end of encasement pipe. Bore and jack applications having an encasement larger in diameter than 24 inches shall be specified by the ENGINEER on a case by case basis.

For all encasement pipe diameter sizes, Model # CCS 14-guage stainless steel casing spacers as manufactured by Cascade Waterworks Mfg. Company or approved equal shall be used. See the MSD standard bore & encasement details 2.14-01 and 2.14-02 for further information.

(k) Casing ends shall be closed with an 8-inch thick brick and mortar bulkhead.

2.15 Tunneling

(a) Tunnel work shall consist of the construction of a tunnel lined with structural steel liner plates, installation of the ductile iron carrier (sewer) pipe, and all materials and labor necessary to prevent flotation as directed by ENGINEER.

(b) Site preparation, excavation, sheeting and shoring, drilling and blasting, backfilling, and the disposal of materials shall be as specified under Item I - Excavation.

(c) The CONTRACTOR shall furnish to the DISTRICT 10 copies of drawings, specifications, and computations for the pit shoring, sealed and signed by a Registered Professional Engineer licensed to practice in the State of North Carolina, and a written description (with shop drawings and detail drawings) of the proposed method of tunnel construction including proposed method of handling groundwater, grouting, handling various soil conditions, carrier pipe installation, and sequence of construction. The method of shoring the pits and method of construction for tunneling operations must be approved by the State Design Services Engineer of the NC Department of Transportation, Division of Highways, or the Norfolk Southern Corporation Engineering Department, as applicable, prior to beginning any work at the site.

(d) The Structural Steel Tunnel Liner Plates shall be of the diameter and gauge shown on the Plans or specified hereafter and shall be galvanized, and bituminous coated. Liner Plates shall be four flange panel type, or two flange type. All Liner Plates for Highway Crossings shall be galvanized, in accordance with the requirements of AASHTO M111-94. Bituminous coating shall meet the requirements of AASHTO M 190. Coatings shall cover the entire surface of the liner plates. The Tunnel Liner Base Metal shall conform to ASTM Specifications A569 and shall be designed in accordance with the requirements of Section 16, Division I, and constructed in accordance with Section 26, Division II of the current or interim Standard Specifications for Highways Bridges, as adopted by the American Association of State Highway and Transportation Officials.

(e) Liner Plates for Railroad Crossings shall be galvanized and bituminous coated and meet the requirements of Norfolk Southern and the manual for Railway Engineering as published by the American Railway Engineering Association (AREA). The minimum mechanical properties of the flat steel plate before cold forming into liner plates shall be:

Tensile Strength of Steel	=	42,000 psi
Yield Strength of Steel	=	28,000 psi
Elongation, 2 inches	=	30 percent

(f) The section properties of the liner plates shall be as specified by the most recent edition of the Standard Specifications for Highway Bridges, adopted by the AASHTO or AREA, as applicable.

(g) Liner Plates shall be handled in such a manner as to prevent bruising, scaling, or breaking of the coating. Any plates that are damaged during handling or placing shall be replaced by the CONTRACTOR at his expense, except that small areas with minor damage may be repaired by the CONTRACTOR as approved by the ENGINEER. Bolts, nuts washers and other accessory hardware shall meet the requirements of ASTM Specification A-307, Grade A and shall be hot-dip galvanized in accordance with the requirements of AASHTO M232 or AREA, as

applicable. Bolts spacing in circumferential flanges shall be in accordance with the manufacturer's standard spacing and shall be a multiple of the plate length so that plates shall be interchangeable and will permit staggering of the longitudinal seams.

(h) All excavation for the entire length of the tunnel shown on the Plans shall be done by tunneling. The periphery of the tunnel shall be trimmed smooth as practical to fit the outside of the liner plates. The tunneling operations shall proceed only a distance sufficient for placing one ring of liner plates. The liner plates shall be installed immediately after the excavated material has been removed. At no time will jetting be allowed.

(i) Where blasting is allowed, only small controlled charges of 40% dynamite or plastic explosives are to be used. The depth of the holes for these charges shall not exceed the depth necessary for clearing an area sufficient for placing one section of tunnel liner. The charges for the initial series of blasting shall be placed in the triangle method. The second series shall be placed in a radial method a minimum distance from the desired diameter of the tunnel. The triangular pattern of charges shall be set to go off first, with the radical charges to go off following a short interval or using the time lag method. Where rock is encountered before approaching the shoulder or pavement, the first four series of charges will be used in determining the amount of controlled blasting to be used before beginning any blasting beneath the shoulders or pavement of the highway; however, if rock is encountered after proceeding beneath the pavement, only small charges shall be used until the proper amount of charge is determined. In no case will an overshoot be permitted. If a boulder is encountered and is removed by blasting or by other methods, a bulkhead will be formed immediately after removal of the boulder and the area filled with grout before proceeding with the tunneling operations. If there is any indication of a vertical split in the rock formation, or any indication of settlement of the roadway or railroad, during the tunneling operations, all operations shall be stopped and the Engineer for the Division of Highways or Railroad shall be notified immediately. If the vertical split is not determined to be of too great a magnitude or too close to the pavement, the split shall be filled with grout at the pressure specified by the Division of Highways Engineer, or the Railroad Engineer and allowed to set and tunneling operations may be continued. If it is determined that the vertical split is of too great a magnitude or too close to the surface, the Division of Highways Engineer or Railroad Engineer shall advise as to the proper method to be used to correct the vertical split. If settlement of the roadway occurs, the Engineer for the Division of Highways or Railroad will advise the DISTRICT and the CONTRACTOR as to the proper steps to be taken to correct the settlement. Item I, Subsection 1.10 "Pre-blast Survey and Vibration Monitoring" of the Specifications apply to blasting during tunnel construction as well as all other blasting. The CONTRACTOR shall communicate with the blasting consultant and coordinate blasting activities to have said consultant on-site to supervise the loading of explosives and monitor the blasts. The CONTRACTOR or any Sub-Contractor shall not load explosives or pull any shots without the blasting consultant present. If at any time the ENGINEER or the blasting consultant determines that the use of explosives is not permissible, other

approved methods of removing the material shall be used. Blasting is not permitted in Railroad Crossings.

(j) The space between the outer face of the liner plates and the inside face of the excavation shall be filled with cement grout. Grout shall contain a minimum of one part Type 1 cement and three parts sand. Grout shall be placed using a pump at sufficient pressure to completely fill all voids created by excavation for installation of the liner plates. The grout shall be pumped through 2-inch diameter grout holes located not more than 4 feet 6 inches on center along the top of the tunnel liner and, if necessary, along the sides to achieve complete grouting. Sufficient plates shall be provided with 2-inch holes and screw type galvanized plugs for final watertight closure of the grout holes. Grouting shall not be more than 6 feet behind the last liner plate ring installed. In addition, all the rings shall be grouted at the end of each day or any other time the tunnel is to be left unattended. Grout will be forced into each grout hole. If the grout from one hold should flow along the liner plate so as to plug the next grout hole, the plugged hole will be opened by punching through the grout layer so that each hole may be used for grouting.

The grouting operation will be continued at each hole until all spaces outside the liner plates are filled and no grout will flow.

(k) The tunnel shall be constructed true to line and grade as shown on the Plans. Variation in alignment and grade is not allowed. The invert elevations of the carrier pipe shall be as specified on the Plans. The actual invert of the tunnel liner shall be proposed by the CONTRACTOR in the submittal of shop drawings. However, sufficient working room, for tie downs and anchoring, shall be provided for, between the top of the carrier pipe and tunnel liner.

(l) After completion of liner plate installation, and prior to the carrier pipe installation, the tunnel shall be thoroughly cleaned of all construction debris, excavated material, grout droppings, rocks, dirt, mud and any other debris. All areas of coating abrasion, scaling, or breaking shall be repaired as directed by the ENGINEER.

(m) The completed liner shall consist of a series of steel liner plates assembled with staggered longitudinal joints. Liner Plates shall be fabricated to fit the cross-section of the tunnel.

(n) Prior to the installation of the carrier (sewer) pipe the CONTRACTOR shall install 2 steel rails, minimum weight of 20 pounds per yard, or steel channel sections, set to line and grade. The rails shall be welded to the cross members prior to placing concrete and shall be spaced such that the ductile iron pipe bells will ride on the rails.

(o) After completion and acceptance of the tunnel, the CONTRACTOR shall install the ductile iron carrier pipe on the steel rails or guide channels to line and grade as shown on the Plans.

(p) Carrier pipe larger than 16 inches diameter shall be held in place by brick and mortar bulkheads placed at each bell. Carrier pipe 16 inches and less shall be anchored to the cross member, and straps shall be secured to the cross members with hooks or other approved fasteners as shown on the Plans. Straps shall be equipped with turnbuckles or ratchet devices for tightening.

(q) Tunnel ends shall be closed with an 8-inch thick brick and mortar bulkhead.

(r) The CONTRACTOR shall make himself familiar with the State and Federal regulations regarding the ventilation and safety for tunneling and mining and the work shall comply with these requirements for protecting the workmen at all times. The CONTRACTOR shall be responsible for the workmen wearing the proper safety attire, obeying safety rules, providing safety equipment including gas detectors, and for providing adequate ventilation at all times.

(s) All shoring materials shall be removed in such a manner so as to avoid collapse and to allow proper backfill. The backfill shall be placed in accordance with the requirements of NCDOT, or the Railroad, and these Technical Specifications.

(t) Upon completion of the tunnel liner installation the CONTRACTOR shall notify the NCDOT Division Engineer, in writing by letter, with a copy to the attention of the State Design Services Engineer, NCDOT, Raleigh, NC, or Norfolk Southern Railroad, as applicable.

2.16 Sewer Service Lines

(a) Where existing sewer mains are being rehabilitated, sewer service lines shall be constructed for each property that is occupied by a business or dwelling if it is currently served by the new construction. For extensions of the existing public system, all buildable lots adjacent to the extension shall have a sewer service line provided.

Additional service lines may be installed by the CONTRACTOR as directed and authorized by the ENGINEER. In general, service lines shall be constructed from the public sewer to a point located at the edge of the public right-of-way or the sewer easement. Service lines shall consist of a 4-inch or 6-inch diameter pipe, as listed in the Bid Schedule and/or shown on the Plans.

(b) The CONTRACTOR shall be responsible to locate and connect all existing sewer service lines, **whether shown or not shown on the construction plans**. In the event a service is missed during construction, the CONTRACTOR shall return to the site and perform all work necessary to reinstate the connection. The CONTRACTOR will be compensated in accordance with the original contract unit pricing; however, re-mobilization to the site will not be paid for.

(c) Service lines built for vacant lots/future connections shall have a cleanout assembly constructed, which includes a 1 foot capped stub-out on the service line. The vertical cleanout pipe shall also be capped, and shall be a minimum of 3 feet above the finish grade.

(d) Service lines 4 inches or less shall be tapped into the sewer main, not into a manhole. Service connections 6 inches or greater shall only be made into an existing or proposed manhole, unless otherwise approved by the ENGINEER.

(e) The DISTRICT-maintained portion of each sewer service line shall have a minimum of 3 feet of cover, unless approved by the ENGINEER.

(f) Sewer service lines and clean-outs shall be Class 350 DIP (with Class 350 appurtenances) if:

1) The service line is installed underneath gravel or paved areas which will have less than 3 feet of cover and will be subjected to traffic loads; or
2) The service line crosses a creek or drainage ditch (whether aerial or subaqueous).

(g) The minimum slope on any residential sewer service line shall not be less than 2 percent, unless approved by the ENGINEER.

(h) Sewer service line connections to sewer mains 12 inches and smaller shall be made with a wye of the same material and joint type as the sewer main. Sewer service connections to sewer mains larger than 12 inches may be made with Romac Saddles, style "CB" as manufactured by Romac Industries, Inc., or approved equal.

(i) Cleanouts shall be constructed at the edge of the permanent easement or at the edge of the public right of way, whichever applies.

In addition, one cleanout shall be constructed for:

1) Every four 45-degree changes located in series (a long sweep is equivalent to two 45-degree bends); and

2) At intervals no greater than 100 feet.

2.17 Deep Services and Maximum Service Grade

(a) When the depth of cut is over 8 feet and the grade of a sanitary sewer is lower than necessary to serve abutting property, and at such other locations as may be designated by the ENGINEER, the CONTRACTOR may install the service line with a 22 ½ or 45 degree bend just upstream of the cleanout assembly to bring the service line up to the necessary elevation.

(b) Unless required service depth is noted on construction Plans, the CONTRACTOR shall contact the ENGINEER and request confirmation of grade prior to constructing any sewer service line at a depth greater than 8 feet.

2.18 Tie-ins to Existing Public or Private Collection Systems

(a) Tie-ins to existing public or private collection systems will be allowed when proper precautions are taken to protect the existing MSD public collection system. Tie-ins to existing inactivated sewer lines not installed under the same contract will not be allowed without written approval from all parties involved (DISTRICT, CONTRACTOR, contract holders, etc.).

(b) If the proposed sewer does not begin at an existing manhole, a new manhole will be "cut in" at the required location and the existing pipe(s) repaired as specified. For extensions of the system, the new "cut in" manhole or the connection to the existing manhole will not be constructed until all other sewer construction has been completed and tested in compliance with the Specifications.

(c) Pipelines or manholes which contain silt, sedimentation, or other foreign material shall not be connected to any portion of the existing public collection system or any private collection system already connected to the DISTRICT's system. The CONTRACTOR shall at his own expense flush, or otherwise cause the line (and manholes) to be cleaned out without any discharge into the existing system.

2.19 Flow Interruptions and Bypass Pumping

(a) When the flow of an existing sewer must be interrupted and/or bypassed, the CONTRACTOR shall, before beginning any construction, submit a work schedule which will minimize the interruption and/or bypassing of wastewater flow during construction. This schedule must be approved by the ENGINEER, and the owners of the private system if connection is to a private system, and may require night, holiday, and/or weekend work.

(b) If pumping is required, an identical standby pump shall be on site in the event of failure of the primary pump. If, at any time during construction, effluent from the existing sewer is not fully contained by the bypass system, gravity service will be restored by a temporary tie to the new construction and work will be suspended until the problem is resolved to the satisfaction of the ENGINEER. The CONTRACTOR shall be responsible for any fines levied as a result of effluent reaching surface waters. The CONTRACTOR will be required to verify his method of handling sewer flows during construction by pumping at peak flows for 1 hour as approved by the ENGINEER.

2.20 Repairs on New Construction

(a) All leaks shall be repaired by identifying and exposing the defective section of pipe and completing repairs. Chemical grouting or internal or external wiping of joints with cement grout are specifically not approved as methods for repairing leaks on new pipelines, regardless of the pipe material approved. Methods of repair are as follows:

(1) VCP: Defective or damaged pipe sections, including leaking joints, shall be removed and replaced with sound new pipe. The pipe or pipe ends shall be re-connected with approved couplings.

(2) PVC or Ductile Iron: Defective or damaged pipe shall be removed and replaced with sound new pipe. The pipe shall be re-connected with approved couplings. Joint leaks shall be cut out and replaced with pipe with mechanical joint sleeves.

(3) RCP: Defective or damaged pipe shall be removed and replaced with sound new pipe. The pipe shall be re-connected with concrete collars or approved couplings. Joint leaks may be repaired with bell clamps specifically approved by the ENGINEER. Concrete collars or repair couplings shall be limited to one every 100 feet not to exceed 3 pipe repairs between manholes. Deficiencies in excess of these limitations shall be corrected by relaying the section of pipe.

(4) Manholes: Defective or damaged manhole components shall be removed and replaced with sound new components unless repairs are approved by the ENGINEER.

(a) Leaks through the manhole joints or walls or around pipe collars, may be repaired with non-shrink or chemical grout applied.

(b) Leaks around boots or gaskets used to join pipe to manholes shall be repaired as recommended by the manufacturer. In the absence of specific recommendations, such leaks shall be repaired by internal grouting with non-shrink or chemical grout.

(c) Lift Holes leaving less than 2 inches of wall thickness shall be plugged from the outside using non-shrink or chemical grout. Penetrating lift holes shall be plugged from the inside and outside using non-shrink grout.

2.21 Abandonment of Existing Sewers and Manholes

(a) Manholes which are to be abandoned shall first have both influent and effluent lines plugged inside the manhole with watertight masonry or concrete. The manhole will then be filled with non-compressible material (crushed stone or as approved by ENGINEER), to a point not less than 3 feet below the finish grade. The remainder of the manhole shall be broken down and removed. Then the excavation shall be

backfilled to finish grade as specified under trench backfill.

(b) Abandoned mains at active manholes shall be completely disconnected from the manhole by cutting the pipe outside the manhole and then plugging the abandoned main and the manhole wall with watertight masonry. The invert shall then be rebuilt to conform to the standard details.

(c) Exposed sections of abandoned mains shall be removed to a point not less than 5 feet from the adjacent banks or surface waters. The remaining ends of the pipe shall be plugged with watertight masonry. Concrete piers or collars in the creek channel shall be removed completely. Concrete piers or collars not located in the creek channel shall be removed to a point 3 feet below the finish grade. Steel piers shall be cut off 3 feet below finish grade.

(d) The minimum length of watertight masonry plugs will be the diameter of the abandoned pipe plus 1 foot.

2.22 Abandoned Sewer Grouting

(a) Existing sewers shall be completely filled with high strength (pressure) grout where indicated on the Plans after the new sewer is placed in service.

(b) High strength (pressure) grout shall be composed of cement, flyash, and water proportioned and mixed to produce a plastic pumpable mixture. Cement shall be portland cement conforming to ASTM Specification C150, Type I. Flyash shall be Type C. Water shall be fresh, clean and free from injurious amounts of oil, acid, alkali, and organic matter.

(c) The following ingredients shall be selected, proportioned and mixed to produce a pumpable, high strength (pressure) grout:

Wt. of cement per cu. yd.	940 lb.
Wt. of flyash per cu. yd.	1,925 lb.
Vol. of water per cu. yd.	60 gal.
Amount of air entrainment in fresh mix	2 % of volume
Retarder	Max. Allowed / 100 WT

(d) Pressure grout shall be pumped into place via a pipe cemented into the sewer line to be grouted full. This pump line shall have vent pipes on each end and the pipe used shall be capable of withstanding the pressure it will be subjected to during the pump process.

2.23 Structural Demolition

(a) Prior to starting construction operations, the CONTRACTOR shall demolish and remove such buildings and other structures as are specifically designated on the plans for removal. Debris shall be removed from project site and disposed of in accordance

with federal, state, and local ordinances at permitted sites. All permits required shall be obtained by the CONTRACTOR.

2.24 Handling and Storage of Materials

(a) The CONTRACTOR shall be responsible for the safe storage of materials furnished by, to, and accepted by him and intended for the work, until the materials have been incorporated in the completed project. The interior of all pipe, manholes and other accessories shall be kept free from dirt and foreign materials at all times.

(b) The CONTRACTOR is responsible for the delivery and site distribution of all materials.

(c) Ductile iron pipe and cast iron accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage. Pipe shall not be loaded, unloaded, or transported by placing lifting forks inside the barrel or the pipe. Concrete pipe, clay pipe, PVC pipe, all pipe accessories, precast concrete manholes, and manhole frame and covers will be unloaded with hoists and/or as recommended by the respective manufacturers. Under no circumstances shall such materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground.

(d) 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. Pedestrian or vehicular traffic shall not be unduly inconvenienced in placing of material along the streets or right-of-way, as applicable.

(e) Except as noted below, the CONTRACTOR will string in advance no more than the amount of pipe and material that can be installed within 4 weeks or less as approved by the ENGINEER. All the materials shall be placed in such a manner as not to hinder access, endanger or impede traffic, or create a public nuisance. For residential areas (or any area with maintained lawns), materials shall be placed in such a manner as not to restrict normal maintenance of established lawns, and must either be installed within 2 weeks or removed to an approved storage yard, as required by the ENGINEER.

(f) The CONTRACTOR will be responsible for locating and providing storage areas for construction materials and equipment. Unless prior written consent from the owner of the proposed storage area is received by the ENGINEER, the CONTRACTOR will be required to store all equipment and materials within the limits of the right-of-way and temporary construction easement provided. The materials and equipment storage shall comply with all local and state ordinances throughout the construction period.

(g) The CONTRACTOR shall be responsible for the safeguarding of materials and equipment against fire, theft, and vandalism and shall not hold the DISTRICT

responsible in any way for the occurrence of same.

(h) At the direction of the ENGINEER, the CONTRACTOR shall remove materials which have been damaged beyond repair from the site to prevent accidental placement.

2.25 Care of Coatings and Linings

(a) Precast manholes, pipe and fittings, including rings and covers, steps, straps, etc., shall be so handled that the coating or lining will not be damaged. If, however, any part of the coating or lining is damaged, the repair shall be made by the CONTRACTOR at his expense in a manner satisfactory to the ENGINEER, or the component shall be replaced at the CONTRACTOR's expense.

2.26 Work Progress and Clean Up

(a) The project site shall be cleaned up in accordance with the requirements of the General Conditions, as the work progresses. Site clean up shall not lag pipe laying more than 500 feet, and site clearing and grubbing shall be limited to 3,000 feet ahead of pipe laying, unless specified or directed otherwise by the ENGINEER.

2.27 Property Owner Notice and Protection of Site

(a) The DISTRICT will secure rights-of-way or easements where required through private lands. The CONTRACTOR shall be responsible for any damage to buildings, walls, fences, utility poles, bridges, utilities, railroad, or other improvements encountered, whether public or private. All such improvements shall be carefully protected from damage and, in case of damage or removal, shall be completely repaired or restored to its original or better condition. All damage to such improvements and all damage to property or persons resulting from damage to such improvements shall be the responsibility of the CONTRACTOR. Special care shall be taken in trenching near buildings, roads and railroads, to avoid or minimize all delays, damage, or injury thereto.

(b) Prior to any operation, the CONTRACTOR shall give advance notice to all property owners and/or tenants within the project.

2.28 Use of Easements and Rights-of-Way

(a) Prior to disturbing any area, the CONTRACTOR shall stake the limits of all easements and/or rights-of-way. The CONTRACTOR shall confine all his operations and personnel within limits of all rights-of-way and easements as shown on the Plans. There shall be no disturbance outside the easement or rights-of-way nor shall the workmen be allowed to travel at will through the surrounding private property, except as provided below. The CONTRACTOR is responsible to note any

areas where limits have been reduced from typical limits. Prior to using any areas outside the rights-of-way and easements provided, the CONTRACTOR shall provide written approval of the current property owner and submit to the ENGINEER for his approval. **The CONTRACTOR shall abide by all Special Provisions Detail Sheets provided in the Special Conditions section of the Specifications.**

2.29 Protection of Designated Trees and Shrubs

(a) Trees, cultivated shrubs, and similar growth which occupy areas outside the limits of public rights-of-way or easements OR are designated in the Special Conditions Detail Sheets to remain undisturbed, shall be carefully preserved and protected by the CONTRACTOR throughout all stages of the construction work. Adherence to the above shall be the responsibility of the Contractor.

(b) The CONTRACTOR shall protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning

and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary fencing to protect trees and vegetation that will be left standing.

(c) The CONTRACTOR shall provide protection for roots over 1-1/2 inches diameter cut during construction operations. Coat cut faces with an emulsified asphalt, or other acceptable coating, formulated for use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out and cover with earth as soon as possible.

(d) The CONTRACTOR shall trim trees scheduled to remain but damaged by construction operations in a manner acceptable to the ENGINEER. Trim damaged trees promptly to prevent progressive deterioration caused by damage.

(e) The CONTRACTOR shall replace trees scheduled to remain and damaged beyond survival or aesthetics, with trees of similar size and species, as approved by ENGINEER. Repair and replacement of trees scheduled to remain and damaged by construction operations or lack of adequate protection during construction operations shall be at the CONTRACTOR's expense. Replacement trees shall be maintained in accordance with project Specifications.

2.30 Clearing Easements and Rights-of-Way

(a) Unless otherwise specified in the Special Provisions Detail Sheets, the entire permanent easement shall be cleared.

(b) Temporary construction easements will be selectively cleared with designated landscape items carefully preserved and protected as stipulated in Special Provisions

Detail Sheets.

(c) Public rights-of-way shall be cleared as shown on the Plans and as stipulated in Special Provisions Detail Sheets. The ENGINEER shall provide copies of tree permits, when required by the City of Asheville.

(d) No clearing or grubbing may be performed on easements obtained by the DISTRICT or in rights-of-way except under supervision of the ENGINEER. Areas to be cleared which are occupied by trees, brush, or other vegetable growth shall be cleared of such growth and suitably grubbed. All large roots or stumps shall be removed to a depth of at least 2 feet below original ground surface. Any pits or cavities thereby created which extend beyond the area to be excavated shall be filled with the materials and in the manner specified for trench backfill in these Specifications. All stumps, limbs and trash shall be removed and disposed of at a location approved for disposal of such materials by the agency having jurisdiction.

(e) Useable timber and/or firewood may be left on the area adjoining the permanent right-of-way at the request of or with the consent of the property owner. The CONTRACTOR must obtain such requests in writing from the property owner. The request must release the DISTRICT from any claims for improper disposal of timber.

(f) When the Special Provisions Detail Sheets specifies stacking timber or firewood adjacent to the permanent right-of-way, a written release is not required. The CONTRACTOR shall verify cut lengths of timber/firewood for such placement and location with each respective property owner.

(g) Fences removed during construction shall be replaced with the same material in the same location and elevation as existed prior to construction, or as provided otherwise in the Special Provisions Detail Sheets. Materials may be re-used if approved by ENGINEER.

2.31 Hubs Set by the CONTRACTOR

(a) As a minimum, centerline hubs and offset stakes will be set by the CONTRACTOR at each manhole.

(b) Pipe lasers shall be used to set line and grade. Elevations shall be verified at each manhole. Fans may be used in conjunction with pipe lasers if necessary. The CONTRACTOR shall keep close check of his pipe laser for variations in line and grade. No variations in line or grade shall be corrected between manholes without relaying that portion of the line which has deviated from line or grade unless otherwise approved by the ENGINEER.

2.32 Steel Straps and Anchors

(a) All pipe straps, anchors, and hardware shall conform to the requirements of ASTM

A36 Grade A with a minimum yield strength of 36,000 psi.

(b) Straps, anchors, and hardware (washers, nuts, etc.) shall be hot dipped galvanized in accordance with ASTM A153, unless otherwise approved.