CHAPTER 11
GRAVITY SANITARY SEWERS

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PART 1 - GENERAL

1.1 SUMMARY

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1.2 RELATED DOCUMENTS

A. All other requirements and provisions of the CHARLOTTE WATER, Water and Sewer Design and Construction Standards, apply to this section.

B. Reference CHARLOTTE WATER Chapter 21 Tunneling & Steel Encasement Specifications for requirements and provisions related to tunneling and encasement.

1.3 DEFINITIONS AND ABBREVIATIONS

A. See Sections iii and iv of the CHARLOTTE WATER Water and Sewer Design and Construction Standards for common abbreviations and definitions.

1.4 SUBMITTALS

A. Product specific submittal requirements may be included in Part 2, Products, under the various products. In addition to product specific submittal requirements, at a minimum, submittals for product approval include, but are not limited to, the following:

1. Product brochures
2. Catalog cut sheets
3. Shop drawings including dimensions and part/material lists

4. Certification of compliance
5. Prior product acceptance test reports
6. Reference contact data
7. Shipping tickets and purchase invoices

B. Provide product data for the following:
1. Ductile-iron, Gravity Sewer Pipe and Fittings
2. PVC Pipe and Fittings
3. Fiberglass Reinforced Polymer Mortar Pipe
4. Aerial Steel Pipe
5. Couplings
6. Service Connections - Tapping Saddles
7. Manholes
8. Parshall Flumes
9. Concrete
10. Miscellaneous Steel
11. Bedding Materials - Stone and Brick/Block
12. Ferrous Castings
13. Micropiles

C. Shop Drawings:
1. A bookmarked and indexed PDF file of shop drawings shall be submitted for review and approval prior to the manufacture, fabrication, and construction.
2. For manholes: At a minimum include plans, elevations, sections, details, steel reinforcement details, structural design sealed by North Carolina Professional Engineer (PE), vent pipe details, manhole connectors, joint sealing information, frames and covers, and buoyancy calculations.
3. For manhole section: The manufacturer shall furnish the Engineer with test results on compression and absorption for one section in every twenty-five sections poured, and certification from cement manufacturer and aggregate supplier certifying chemical content. The Engineer reserves the right to pick random sections for the required testing.
4. For manhole steps: The manufacturer shall submit certification and test results that each step has been tested in accordance with ASTM C-478, plus additional testing requirements of this specification.

D. Product Certificates: Required for all products.

E. PVC Closed Profile Sewer Piping: One sample of each size pipe specified, from each production run (or one per truck load) for the project, shall be tested in accordance with the requirements of ASTM F-1803. The manufacturer shall submit certification and test results that the pipe has been tested in accordance with ASTM F-1803 as applicable and has been found to meet all requirements of this specification. Test samples shall be as selected by the manufacturer or testing laboratory unless otherwise stipulated in the project specific Special Provision Section.

F. Solid Wall PVC Pipe Testing Requirements: The manufacturer shall submit certification and test results that the pipe has been tested in accordance with AWWA C-900 and has been found to meet all requirements. Test samples shall be as selected by the manufacturer or testing laboratory unless stipulated otherwise. 8" DR 26 PVC pipe and fittings shall be manufacturer tested in accordance with ASTM D-3034 and the manufacturer shall submit certification and test results indicating that all requirements are met.

G. Reinforced Polymer Mortar Pipe Testing Requirements: Testing Requirements shall be as specified in Section 2.3.B.3 of this specification.

H. Ductile Iron Pipe Testing Requirements: The manufacturer shall perform the standard acceptance tests required by AWWA C-151, Section 5.1.1.2 and shall keep test records on file for inspection by the Engineer. The manufacturer shall furnish an affidavit that the materials used in the making of the pipe meet all provisions of the applicable AWWA and ASTM standards and that the pipe, fittings, accessories, and rubber gaskets meet all applicable provisions of AWWA C-104, C-110, C-111 C-115, C-150, and C-153 respectively.

I. Aerial Steel Pipe Testing Requirements:

1. The pipe shall be manufactured and tested in accordance with ASTM A53. The product markings shall be marked on the inside of the bell or spigot ends and shall be a waterproof marking material. The minimum pipe markings shall include the manufacturer's name or trademark, the production year, piece number per the laying schedule and the pressure rating. Beveled pipe shall be marked with the amount of bevel and the point of maximum pipe length shall be marked on the beveled end. All markings shall be clear and legible.

2. Shop Tests

    a. After the joint configuration is completed and prior to lining with cement mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 percent of the yield strength of the steel.

    b. The test pressure shall be held for 2 minutes, and the pipe visually inspected to confirm that welds are sound and leak-free.

3. In addition to the tests required in ASTM A53 and A139, weld tests shall be conducted on each 5,000-feet of production welds and at any other times there is a change in the grade of steel, welding procedure, or welding equipment.

4. The Engineer reserves the right to witness any or all acceptance tests. Prior notice of testing schedules will be provided by the manufacturer to the Engineer to accommodate travel or independent third party witness arrangements.

I. Qualification Data: For qualified testing agency.

J. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.

2. Laboratory compaction curve according to ASTM D 698.

K. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. For Donated Projects, these requirements apply to existing road rights-of-way only. Submit before earth moving begins.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight. All pipe must be in brand new factory condition, and no more than one year old from manufacturer date to installation. Pipe manufacturer must provide letter regarding exposure requirements.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

D. The Contractor shall be responsible for the safe storage of materials furnished by or to them, and accepted by them and intended for the work, until they have been incorporated in the completed project. Handling and storage of all project materials are to be in compliance with the manufacturer's recommendations for handling and storage. The interior of all pipe, manholes and other accessories shall be kept free from dirt and foreign materials at all times.

E. Transportation of Materials and Equipment: The Contractor and their Suppliers are directed to contact the North Carolina Department of Transportation to verify axle load limits on State maintained roads (and bridges) which would be used for hauling of equipment and materials for this project. The Contractor and their Suppliers shall do all that is necessary to satisfy the Department of Transportation requirements and will be responsible for any damage to said roads which may be attributed to this project. All materials required to construct this project shall be furnished by the Contractor and shall be delivered and distributed at the site by the Contractor or their material supplier.

F. Loading and Unloading Materials: 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 and precast manholes 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.

G. Responsibility for Materials on Site: 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. Each piece shall be redundantly chocked at each end to prevent movement or rolling. Pedestrian or vehicular traffic shall not be unduly inconvenienced in placing of material along the streets or right-of-way, as applicable.

The Contractor will string in advance no more than the amount of pipe and material that can be installed within two (2) weeks unless approved by the Engineer. All the materials shall be placed in such a manner as not to hinder access, endanger or impede traffic, create a public nuisance or endanger the public.

Materials strung through residential areas (or any area with maintained lawns) shall be placed in such a manner as not to restrict normal lawn maintenance, and must either be installed within two (2) weeks or removed to an approved storage yard, as required by the Engineer.

H. Material and Equipment Storage Sites: Unless otherwise shown on the plans, 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 CHARLOTTE WATER, the Contractor will be required to store all equipment and materials within the limits of the project site, or the limits of the sanitary sewer 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. Material and equipment may only be stored within road right-of-way if approved by the controlling agency. Bulk storage of stacked materials shall not be permitted in or along road rights-of-way.

Storage sites shall be fenced with adequate protection to reasonably prevent the public from entering the site. The Contractor shall be responsible for the safeguarding of materials and equipment against fire, theft, and vandalism and in a manner which does not place the public at risk, and shall not hold the City responsible in any way for the occurrence of same.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to CHARLOTTE WATER requirements indicated:

1. Notify Engineer and Owner no fewer than three (3) days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner's permission.

PART 2 - PRODUCTS

2.1 PIPE, GENERAL

A. All materials furnished in accordance with these specifications shall be new and unused, unless otherwise specified in the project Special Provisions. Unless superseded or modified by a Special Provision, all materials, apparatus, supplies, methods of manufacture, or construction shall conform to the specification for same contained in this Section. National material standards (ASTM, ANSI, etc.) referred to herein shall be considered to be the latest revisions only.

2.2 DUCTILE-IRON, GRAVITY SEWER PIPE AND FITTINGS

A. Pipe: At a minimum, all Ductile iron pipe shall conform to the requirements of AWWA Standard C-151 and ASTM A-746. Unless otherwise shown on the construction plans, all ductile iron pipe shall be furnished with push-on joints or restrained joints in accordance with AWWA C-111, and cement mortar lining.

1. Pipe (12-inch diameter and smaller): AWWA C151/A21.51, ASTM A-746, minimum pressure class 350, with cement mortar lining of standard or double thickness in accordance with AWWA C104.
2. Pipe (16-inch to 64-inch diameter): AWWA C151/A21.51, ASTM A-746, minimum pressure class 250, with cement mortar lining of standard or double thickness in accordance with AWWA C104.
3. The pipe class selection for all diameters shall be based on the installation conditions and existing or proposed depth of cover. Special thickness class pipe up to and

including thickness class 56 shall be required when specified, based on installation conditions and depth of cover.

4. The pipe shall contain all product markings required by ASTM A-746 and AWWA C-151. The minimum pipe markings shall include the weight, class or nominal thickness, casting date. The manufacturer's mark, the country where cast, the production year, and the letters "DI" or "DUCTILE" shall be cast or metal stamped on the pipe, and on pipe sizes 14-inch and larger shall not be less than ½-inch in height. All markings shall be clear and legible, and all cast or metal-stamped marks shall be on or near the bell.

5. Manufacturers:

   a. DIP shall be as furnished by American Cast Iron Pipe, McWane Cast Iron Pipe or US Pipe Company.

B. Fittings

1. Standard Fittings: AWWA C110/A21.10, ductile with cement mortar lining of standard or double thickness in accordance with AWWA C104.

2. Compact Fittings: AWWA C153/A21.53, with cement mortar lining of standard or double thickness in accordance with AWWA C104.

3. The fittings shall contain all product markings required by AWWA C-110 or C-153 as applicable. The minimum markings on each fitting shall include the identity of the AWWA standard, the pressure rating, nominal diameters, manufacturer's identification, the county where cast, the letters "DI" or "DUCTILE", and the angle of all bends. The markings shall be distinctly cast raised or in relief on the outside of the fitting body.

4. Ductile iron fittings may be mechanical joint, slip joint, or restrained joint.

5. Manufacturers:

   a. DI fittings 24-inch and smaller in diameter shall be manufactured within the North American Continent or imported by an approved importer/manufacturer. DI fittings shall be as furnished by American Cast Iron Pipe, McWane Cast Iron Pipe, Star Pipe Products, Sigma Corporation, SIP Industries, Tyler Pipe, or US Pipe Company only.

   b. DI fittings 30-inch and larger in diameter shall be manufactured within the North American Continent by an approved manufacturer. DI fittings shall be as furnished by American Cast Iron Pipe, McWane Cast Iron Pipe, Tyler Pipe/Union or US Pipe Company only.

C. Gaskets: AWWA C111/A21.11, Styrene Butadiene Rubber (SBR), of shape matching pipe and fittings. Nitrile (NBR) rubber (acrylonitrile butadiene) gaskets shall be furnished when specified or shown on the construction plans and when sewer mains are located near contaminated soils or gasoline storage facilities. EPDM gaskets shall be furnished when specified or shown on the construction plans.

D. When specified or shown on the approved constructions plans, ductile iron pipe and fittings shall be epoxy lined (Induron Protecto 401, Tnemec Perma-Shield PL Series 431, Permite Permox CTF or approved equal), or shall have fusion-bonded epoxy lined/coating in accordance with AWWA C116. The interior of the pipe shall receive 40 mils nominal dry film thickness, or as indicated by the coating manufacturer.

E. The Engineer reserves the right to witness any or all acceptance tests. Prior notice of testing schedules will be provided by the manufacturer to the Engineer to accommodate travel or independent third-party witness arrangements.

F. Corrosion Protection: When indicated on the plans, corrosion protection equipment and installation shall be in accordance CHARLOTTE WATER standard specifications for Corrosion Control as indicated in Chapter 18.

2.3 PVC PIPE AND FITTINGS

A. PVC Closed Profile Sewer Piping:

1. Pipe: Sewer pipe 30-inch and larger may be Closed Profile PVC sewer pipe manufactured in accordance with ASTM F1803 and tested in accordance with ASTM D2122, ASTM D2152, ASTM D2412, and ASTM D2444 with a minimum pipe stiffness of 46 PSI in accordance with ASTM D2412. Required pipe stiffness shall be based on loading and bedding conditions. Pipe stiffness may be 46, 60 or 75 PSI. Pipe cell classification 12454 or 12364. All seams on the completed pipe shall be heat welded (thermally fused). Glued seams will not be allowed.

2. Pipe joining shall be push-on elastomeric joints only and joints shall be manufactured in accordance with ASTM Specification D-3212. The pipe shall be furnished with integral bells and with gaskets that are permanently installed at the factory.

3. Fittings: Fittings shall be in accordance with ASTM D-3212, and/or D-3034 as applicable, with stiffness and wall thickness equal to or greater than the pipe. Adapters shall be provided to join different materials.

4. Gaskets: ASTM F 477, elastomeric seals. The lubricant used for assembly shall be as recommended by the manufacturer and shall have no detrimental effect on either the pipe or the rubber gasket.

5. The pipe shall contain all product markings required by ASTM F-1803. The minimum pipe markings shall include manufacturer's name, nominal pipe size, PVC cell classification 12454 or 12364, wall stiffness number "PS 46 PVC Sewer Pipe", and ASTM designation - ASTM F-1803.

6. Color Requirements: PVC Solid Wall Sewer Pipe and Fittings for sanitary sewer shall be green or white in color.

7. Manufacturers:

   a. PVC Closed Profile Sewer Pipe shall be manufactured within the North American Continent and shall be furnished by the following or pre-approved equal:

   b. Trenchless Resources Global Holdings (Vylon Pipe) – F1803

B. PVC Solid Wall Sewer Piping

1. Uses: Unless otherwise indicated on the Project Plans, Sewer pipe 8 inches through 30 inches in diameter may be Solid Wall DR 25 PVC sewer pipe manufactured in accordance with AWWA C900. PVC Solid Wall PVC pipe used for lateral piping on C900 PVC sewer pipe lines must be manufactured in accordance with AWWA C900.

2. Pipe: Sewer pipe 8 inches through 30 inches in diameter may be Solid Wall PVC sewer pipe manufactured in accordance with AWWA C900. The pipe shall be furnished with integral bells and with gaskets that are permanently installed at the factory. The pipe shall be furnished in nominal lengths of 13, 20 or 22 feet. Shorter lengths will be accepted to allow for the proper placement of fittings. PVC sewer pipe shall be green in color.

    a. 6-inch and smaller PVC pipe shall be Dimension Ratio (DR) 18.

    b. 8-inch and larger PVC pipe shall be Dimension Ratio (DR) 25.

3. All PVC Sewer Pipe will be shipped, stored, and strung at the project in such a manner as to be protected from total accumulated exposure to sunlight and possible ultraviolet radiation for no more than one year from the manufacturer date.

4. Fittings: 12-inch and smaller fittings shall comply with or exceed AWWA C907. Fittings shall be gasketed joint of one piece and injection molded of PVC compound with a cell class 12454 per ASTM D1784. Fittings shall be pressure rated at 235 PSI and shall have a Dimension Ratio (DR) of 18.

5. The fittings shall contain all product markings required by AWWA C-907 as applicable. The minimum markings on each fitting shall include the identity of the AWWA standard, the pressure rating, nominal diameter and deflection angle is applicable, manufacturer's identification, and maximum allowable joint deflection for each gasket joint. The markings shall remain legible during normal handling, storage and installation.

6. 14-inch and larger fittings shall be molded one piece fittings as specified above, or shall be fabricated from AWWA C-900 pressure rated pipe, and shall have a Dimension Ratio (DR) of 18. Fabricated fittings shall be submitted for approval. They shall be manufactured to meet the requirements of the same specifications and shall have the same diameter and thickness as standard fittings, but their laying lengths and types of ends (bell or spigot x bell) shall be determined by their position in the pipelines and by the particular piping to which they connect.

7. Gaskets: ASTM F 477, elastomeric seals. Gasket lubricant shall be as recommended by the pipe manufacturer.

8. Color Requirements: PVC Solid Wall Sewer Pipe and Fittings for sanitary sewer shall be green or white in color.

9. Manufacturers:

    a. PVC AWWA C-900 pipe shall be manufactured within the North American Continent and shall be furnished by the following or pre-approved equal:

        1) North American Pipe Corporation, NAPCO

        2) JM Eagle

        3) Diamond Plastics

        4) National Pipe

        5) Sanderson Pipe

    b. PVC fittings shall be manufactured within the North American Continent and shall be furnished by the following or pre-approved equal:

        1) North American Pipe Corporation, NAPCO

2) IPEX

3) HARCO (Harrington Corporation)

4) Multi Fittings Corporation

5) GPK Products, Inc.

10. PVC Solid Wall Sewer Pipe for Cleanouts, Standpipes, and Tailpieces.

a. White solid wall schedule 40 pipe for cleanouts, standpipes, and tailpieces shall be in accordance with ASTM D-2665, NSF 14, and D-1785. Fittings shall be socket type in accordance with ASTM D-2466. PVC material shall be PVC1120, PVC1220 or PVC2120. Joining shall be through solvent cement in accordance with ASTM D-2564.

b. Gray solid wall schedule 80 pipe is allowed for lateral installation in an uncased bore.

c. The pipe shall contain all product markings required by ASTM D-1785, or ASTM D-2665. The minimum pipe markings shall include manufacturer's name or trademark, ASTM designation "ASTM D-1785 or D-2665", nominal pipe size, type of plastic material such as "PVC1120"pipe", Schedule 40 or Schedule 80, and production code including year, month, day, shift, plant and extruder. Markings shall be at intervals of not more than 5 feet.

d. The fittings shall contain all product markings required by ASTM D-1785, or ASTM D-2665. The minimum markings on fittings shall include manufacturer's name or trademark, and the pipe material "PVC". Markings shall be on the body or the hub.

e. Product shall be manufactured at a facility that has a Registered ISO 9001:2000 Quality Management System. Copy of current ISO 9001:2000 registration shall be submitted with product submittals.

f. Required submittals for product approval include, but are not limited to, product brochure, catalog cuts or shop drawings including dimensions and part/material list, certification of compliance, prior product acceptance test reports, and reference contact data.

g. Color Requirements: PVC Solid Wall Sewer Pipe and Fittings for cleanouts, standpipes, and tailpieces shall be white in color for Schedule 40 and gray for Schedule 80.

h. PVC pipe and fittings shall be manufactured within the North American Continent. An officer of the manufacturing company shall certify that all pipe and fittings were manufactured in North America.

i. Manufacturers:

1) North American Pipe Corporation, NAPCO

2) JM Eagle

3) National Pipe

4) Sanderson Pipe

C. PVC Solid Wall Sewer Piping: DR 26

1. Uses: Sewer pipe 8 inches in diameter may be Solid Wall DR 26 PVC sewer pipe manufactured in accordance with ASTM D3034 and ASTM D1784. Solid Wall PVC pipe used for lateral piping on DR 26 mains shall also be allowed to be Sch 40 PVC and must be manufactured in accordance with ASTM D1785.

2. Pipe:

   a. Sewer main pipe 8 inches in diameter shall be Solid Wall PVC sewer pipe manufactured in accordance with ASTM D3034. The pipe shall be furnished with integral bells and with gaskets that are permanently installed at the factory. The pipe shall be furnished in nominal lengths of 14 or 20 feet. Shorter lengths will be accepted to allow for the proper placement of fittings. PVC sewer pipe shall be green in color.

      1) 8-inch PVC pipe shall be Standard Dimension Ratio (DR) 26

      2) Fittings shall be manufactured in accordance with ASTM D3034 and ASTM F1336. They shall be injection molded from virgin PVC compound of cell classification 12454 to meet ASTM D1784.

      3) Gaskets shall be manufactured in accordance with ASTM F477. Gasket lubricant shall be as recommended by the pipe manufacturer.

      4) Joints shall be in accordance with ASTM D3212.

      5) Color Requirements: PVC Solid Wall Sewer Pipe and Fittings for sanitary sewer shall be green or white in color.

      6) DR 26 PVC pipe and fittings shall be manufactured within the North American Continent. An officer of the manufacturing company shall certify that all the pipe and fittings were manufactured in North America.

      7) Pipe Manufacturers:

         a) North American Pipe Corporation (NAPCO) / Westlake

         b) JM Eagle

         c) Diamond Plastics

         d) National Pipe

         e) Sanderson Pipe

         f) Or, pre-approved equal

      8) Fitting Manufacturers:

         a) North American Pipe Corporation (NAPCO) / Westlake

         b) IPEX

         c) HARCO (Harrington Corporation)

         d) Multi Fittings Corporation

         e) GPK Products, Inc.

         f) Or, pre-approved equal

   b. Lateral pipe 4-inches and 6-inches shall be Solid Wall PVC pipe manufactured in accordance with ASTM D1785 and ASTM D2665. Fittings

shall be socket type in accordance with ASTM D2466. PVC material shall be PVC1120, PVC1220 or PVC2120. Joining shall be through solvent cement in accordance with ASTM D2564. The pipe shall be furnished in nominal lengths of 10 or 20 feet. Shorter lengths will be accepted to allow for the proper placement of fittings.

1) The pipe shall contain all product markings required by ASTM D-1785, or ASTM D-2665. The minimum pipe markings shall include manufacturer's name or trademark, ASTM designation "ASTM D-1785 or D-2665", nominal pipe size, type of plastic material such as "PVC1120"pipe", Schedule 40, and production code including year, month, day, shift, plant and extruder. Markings shall be at intervals of not more than 5 feet.

2) The fittings shall contain all product markings required by ASTM D-1785, or ASTM D-2665. The minimum markings on fittings shall include manufacturer's name or trademark, and the pipe material "PVC". Markings shall be on the body or the hub.

3) Product shall be manufactured at a facility that has a Registered ISO 9001:2000 Quality Management System. Copy of current ISO 9001:2000 registration shall be submitted with product submittals.

4) Required submittals for product approval include, but are not limited to, product brochure, catalog cuts or shop drawings including dimensions and part/material list, certification of compliance, prior product acceptance test reports, and reference contact data.

5) Color Requirements: PVC Solid Wall Sewer Pipe and Fittings for cleanouts, standpipes, and tailpieces shall be white in color for Schedule 40.

6) PVC pipe and fittings shall be manufactured within the North American Continent. An officer of the manufacturing company shall certify that all pipe and fittings were manufactured in North America.

7) Manufacturers:

a) North American Pipe Corporation, NAPCO

b) JM Eagle

c) National Pipe

d) Sanderson Pipe

3. All PVC Sewer Pipe will be shipped, stored, and strung at the project in such a manner as to be protected from total accumulated exposure to sunlight and possible ultraviolet radiation for no more than one year from the manufacturer date.

2.4 FIBERGLASS REINFORCED POLYMER MORTAR PIPE

A. Uses: Unless indicated otherwise on the project plans, sewer pipe 30 inches and larger in diameter may be Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) reinforced polymer mortar (FRPM) pipe.

B. Performance / Design Criteria

1. Pipe

a. The pipe shall be manufactured by the casting process to produce a dense, nonporous, corrosion-resistant, consistent composite structure. The pipe shall be manufactured and tested in accordance with ASTM D-3262, AWWA C950 and AWWA M-45. Joints shall be filament wound sleeve type couplings with an elastomeric membrane seal. Joints shall perform in accordance with the requirements of ASTM D-4161.

b. Design pipe for service loads that include:

1) External groundwater and earth loads

2) Jacking/pushing loads

a) The allowable jacking/pushing capacity shall not exceed 40 percent of the ultimate compressive strength, or the maximum allowable compressive strength recommended by the manufacturer, whichever is less.

3) Traffic loads

4) Practical considerations for handling, shipping and other construction operations

c. Design is to be conducted under the supervision of a Professional Engineer licensed in the State of North Carolina, who shall seal and sign the design.

d. Pipe shall be supplied in nominal lengths of 20, 30 or 40 feet. Actual laying length shall be nominal +1 or -4 inches. At least 90% of the total footage of each size and class of pipe, excluding special order lengths, shall be furnished in nominal length sections.

e. Minimum pipe stiffness when tested shall be in accordance with ASTM D2412. The minimum pipe stiffness shall not be less than SN 72 psi unless otherwise shown on the drawings and recommended by the manufacturer given consideration of the field condition, applicable loading, depth, trench width, water table and 100-year flood plain elevation. The pipe stiffness for each segment must also be approved by the CHARLOTTE WATER.

f. Accommodate vertical alignment changes required because of existing utility or other conflicts by an appropriate change in pipe design depth.

g. In no case shall pipe be installed deeper than its design allows.

2. Dimensional Tolerances

a. Outside diameter

1) Pipe shall be outside diameter (OD) controlled pipe size and shall not vary in tolerance more than +0.08-inch or -0.06-inch, per ASTM D3262

b. Wall thickness

1) Provide minimum single point thickness no less than 98 percent of stated design thickness.

c. End Squareness

1) Provide pipe ends square to pipe axis with maximum tolerance of 1/4 inch or 0.5% of the nominal diameter.

d. Fittings

1) Provide tolerance of angle of elbow and angle between main and leg of tee to ±2 degrees.

2) Provide tolerance of laying length of fitting to ±2 inches.

3. Inspection and Testing During Fabrication

a. The Contractor, during the fabrication of the pipe, shall retain at his expense the services of a testing laboratory to make all tests of materials to be incorporated into the pipe and maintain control of the acceptance of these materials for fabrication of the pipe.

b. At a minimum, actual test results shall be required as follows:

1) Load bearing tests: Provide test results for the first joint manufactured of each size and class, and at least one joint per hundred joints thereafter.

2) Material tests: Provide material test results per the ASTM and AWWA Standards.

c. Each piece of pipe shall bear the approval stamp of the testing laboratory. The selection of the testing laboratory shall be subject to the approval of CHARLOTTE WATER and its work subject to the Engineer's review.

1) Load bearing tests: Provide test results for the first joint manufactured of each size and class, and at least one joint per hundred joints thereafter.

2) Material tests: Provide material test results per the ASTM and AWWA Standards.

d. CHARLOTTE WATER or other designated representative shall be entitled to inspect pipes or witness the pipe manufacturing. Such inspection shall not relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.

e. Should CHARLOTTE WATER request to see specific pipes during any phase of the manufacturing process, the manufacturer must provide CHARLOTTE WATER with adequate advance notice of when and where the production of those pipes will take place.

f. Should CHARLOTTE WATER elect not to inspect the manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

g. An inspection of the pipe after delivery to the project shall be made by a representative of CHARLOTTE WATER. Pipe with visible defects which are indicative of poor structural condition or poor workmanship shall be rejected and replaced without cost to CHARLOTTE WATER. Visible defects shall include cracks of any type, honeycombs, delamination, or any other defects of poor workmanship. Any pipe rejected shall not be returned under any condition to the project.

C. Materials

1. Resin Systems

a. Only use polyester resin system with proven history of performance in this particular application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product. The internal liner resin shall be suitable for service as sewer pipe and shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases.

2. Glass Reinforcements

a. Use reinforcing glass fibers of highest quality commercial grade E-glass filaments with binder and sizing compatible with impregnated resins to manufacture components.

3. Fillers

a. Silica sand or other suitable materials may be used.

b. Use 98 percent silica with maximum moisture contest of 0.2 percent.

4. Additives

a. Resin additives, such as curing agents, pigments, dyes, fillers, thixotropic agents, etc., when used, shall neither detrimentally affect the performance of the product nor impair visual inspection of the finished products.

5. Internal liner resin

a. Suitable for service as sewer pipe

b. Highly resistant to exposure to sulfuric acid

c. Produced by biological activity from hydrogen sulfide gases

d. Meet or exceed requirements of ASTM D3681

6. Gaskets

a. Supply from approved gasket manufacturer in accordance with ASTM F477 and suitable for service intended.

b. Affix gaskets to pipe by means of suitable adhesive or install in a manner so as to prevent gasket from rolling out of pre-cut groove in pipe or sleeve coupling.

c. Provide the following gaskets in potentially contaminated areas.

1) Petroleum (diesel, gasoline) – Nitrile

2) Other contaminants – Manufacturer recommendation

7. Couplings

a. Field connect pipe with fiberglass sleeve couplings that utilize elastomeric sealing gaskets as sole means to maintain joint water tightness.

8. Joints

a. All pipes so joined shall be made from the same class and type of raw material made by the same raw material supplier.

b. Joints must meet requirements of ASTM D4161.

c. Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings or bell-spigot joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness.

d. Joints at tie-ins, when needed, may utilize fiberglass, gasket-sealed closure couplings.

9. Pipe markings shall meet the minimum requirements of ASTM D3236. Minimum pipe markings shall be as follows:

a. Manufacturer

b. Manufacturer Number (identifies factory, location, date manufactured, shift and sequence)

c. Nominal diameter

d. Beam load

e. Laying length

f. ASTM designation

10. Connections

a. Unless approved by CHARLOTTE WATER, material changes shall only occur at manholes.

b. Flanges, elbows, reducers, tees, laterals and other fittings shall be capable of withstanding all operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass-fiber-reinforced overlays. Properly protected standard ductile iron, fusion-bonded epoxy-lined iron and stainless-steel fittings may also be used.

c. Closures may be accomplished using a special closure kit, fiberglass gasket-sealed closure couplings, flush fiberglass bell-spigot joints, or other method approved by the Engineer. Location of closures shall be subject to the approval of the Engineer.

D. Manufacturing and Construction

1. Manufacture pipe by the centrifugal casting or filament wound process to result in a dense, nonporous, corrosion-resistant, consistent composite structure. The interior surface of the pipes exposed to sewer flow shall be manufactured using a resin with a 50% elongation (minimum) when tested in accordance with ASTM D638, or a glass reinforced resin liner system. The interior surface shall provide crack resistance and abrasion resistance. The exterior surface of the pipes shall be comprised of a sand and resin layer or a glass reinforced resin layer which provides UV protection to the exterior. Pipes shall be Type 1, Liner 1 or 2, Grade 1 or 3 per ASTM D3262.

E. Color Requirements: FRPM Pipe and Fittings for sanitary sewer shall be green or white in color if available.

F. Submittals: Required submittals for product approval include, but are not limited to, product brochure, catalog cuts or shop drawings including dimensions and part/material list, certification of compliance, prior product acceptance test reports, and reference contact data.

G. Storage and Handling: Pipe shall be handled only from the outside of the pipe using woven slings. No forks, chains, straps, hooks, etc. shall be placed inside the pipe for lifting, positioning, or laying.

H. Manufacturers

1. Product shall be manufactured at a facility that has a Registered ISO 9001:2000 Quality Management System. Copy of current ISO 9001:2000 registration shall be submitted with product submittals.

2. Fiberglass reinforced polymer mortar (FRPM) pipe and fittings shall be manufactured within the North American Continent. An officer of the manufacturing company shall certify that all FRPM pipe and fittings were manufactured in North America. Pipe shall be furnished by the following manufacturers or pre-approved equal:

a. Hobas Pipe USA, Inc.

b. Flowtite® as manufactured by Thompson Pipe Group

c. Fiberstrong® as manufactured by Future Pipe Industries

2.5 AERIAL STEEL PIPE

A. Steel Pipe (Aerial Crossings, 40-foot maximum length for 8-inch and 10-inch diameter pipe and 50-foot maximum length for 12-inch and larger diameter pipe):

1. High Strength Steel Pipe shall be seamless, straight seam, or spiral weld, manufactured in accordance with ASTM A-53 for Welded and Seamless Steel Pipe (8-inch to 24-inch inclusive) and/or ASTM A-139 for Welded Straight- Seam Steel Pipe (8-inch to 92-inch inclusive).

2. All steel shall be Grade "B" only, with minimum yield strength of 35,000 PSI. Thickness shall be 0.250" unless otherwise specified or shown on the plans.

3. The pipe shall be produced in a single continuous length. Welding of two or more individual pieces together end to end shall not be permitted.

4. All steel pipe shall receive shop applied linings on the inside of pipe barrel as follows:

a. Minimum 15 mils dry film thickness of Tnemec Perma-Shield PL Series 431, or approved equal, or shall have fusion-bonded epoxy coating in accordance with AWWA C213).

b. Surface preparation and application shall be as recommended by Tnemec or approved equal manufacturer. Applicator shall be a Tnemec, or approved equal manufacturer, approved certified applicator.

c. Lined pipe shall be handled only from the outside of the pipe using woven slings. No forks, chains, straps, hooks, etc. shall be placed inside the pipe for lifting, positioning, or laying.

5. The outside of steel pipe shall receive one or more shop applied coats to the complete exterior surface of the pipe barrel, conforming to the following:

a. Minimum 20 mils dry film thickness of Tnemec Perma-Shield PL Series 431 or approved equal, or shall have fusion-bonded epoxy coating in accordance

with AWWA C213. Exterior coating shall be black, or as approved by the Engineer. Submit 6-inch square sample paint chip for review and approval.

b. Surface preparation and application shall be as recommended by Tnemec or approved equal manufacturer. Applicator shall be a Tnemec, or approved equal manufacturer, approved certified applicator.

c. Coated pipe shall be handled only from the outside of the pipe using woven slings. No forks, chains, straps, hooks, etc. shall be placed inside the pipe for lifting, positioning, or laying.

d. Damage to exterior coatings shall be repaired with the same coating used by the manufacturer and applied as recommended by the manufacturer.

6. Pipe ends shall have tolerances within the limits required for approved couplings. Pipe shall also be furnished with plain right-angle ends with all burrs removed from the ends.

7. Pipe transition couplings shall be AWWA C-110 or AWWA C-153 ductile iron long pattern solid sleeves. For transition from steel pipe to ductile iron pipe, use a standard MJ gland pack with oversize transition gasket on the steel pipe, and a wedge action joint restraint gland on the ductile iron pipe end.

8. Pipe couplings for steel pipe to steel pipe segments shall be AWWA C110 or C153 ductile iron long pattern solid sleeves. A standard MJ gland pack with oversize transition gasket shall be used on each end connection to the steel pipe.

9. Couplings and glands shall receive field applied protective coatings as specified for steel pipe.

10. Manufacturers

a. Steel pipe and fittings shall be manufactured within the North American Continent. An officer of the manufacturing company shall certify that all steel pipe and fittings were manufactured in North America. Pipe shall be furnished by the following manufacturers or pre-approved equal:

1) American

2) U.S. Steel Tubular Products

3) American Piping Products

B. Aerial crossings shall utilize pipe crossing pedestrian fan guards as shown on the Standard Details.

1. Coatings: All guard components shall receive one or more shop applied coats to the complete exterior surface as detailed above for exterior pipe coatings.

2.6 COUPLINGS (FOR REPAIRS TO EXISTING PIPING ONLY)

A. Flexible Transition Couplings used to join various types of pipe (VCP, PVC etc.) to ductile iron pipe, shall be elastomeric PVC or natural rubber sleeve couplings with external stainless steel compression bands and external stainless steel shear rings. Bushings of like material may be used inside the coupling to accommodate pipes of differing outside diameters. The coupling shall provide a watertight connection at a minimum test pressure of 4.3 PSI. Couplings shall conform to the requirements of ASTM C-1173 and as modified below. The minimum coupling length and shear band requirements shall be:

1. Diameter 6” through 12”: Minimum Coupling Length is 6-inch. Shear Band Required

2. Diameter 15” through 24”: Minimum Coupling Length is 10-inch. Shear Band Required

3. Diameter 30” through 72”: Minimum Coupling Length is 12.5-inch. Shear Band Not Required

B. External shear bands shall be ASTM A-167/A-240 series 300 stainless steel, minimum thickness of 0.012-inches, and shall cover the coupling from compression band to compression band. Exterior compression bands clamps, bolts and nuts shall be ASTM A-167/A-240 series 300 stainless steel. Clamps shall be nut and bolt, or T-Bolt design. Couplings 30-inches and larger without the shear bands shall require 2 compression bands at each end of the coupling, and a minimum 3/8-inch thick coupling with multiple sealing ribs.

C. Couplings 24-inches and smaller shall be Mission Rubber Company Flex-Seal Adjustable Repair Couplings (ARC), Fernco Strong Back RC Series Repair Coupling, or approved equal. Couplings 30-inches and larger shall be Mission Rubber Company Flex-Seal Couplings, Fernco Large Diameter Coupling, or approved equal.

D. Transition Adaptors: Transitions adaptors for 12-inch diameter and smaller pipe may be PVC or DIP as specified below:

1. PVC Transition adaptors may be used for 12-inch and smaller pipe. PVC Transition Couplings used to join PVC sewer OD pipe to ductile iron OD pipe, shall be PE sewer spigot x DIOD gasket bell or PE DIOD spigot x sewer gasket bell. Adaptors shall be one piece PVC and conform to the requirements of ASTM D-3034 with a minimum wall thickness equal to or greater than the adjacent sewer pipe. Transition adaptors shall be as manufactured by HARCO or approved equal.

2. Ductile Iron Transition adaptors may be used for 12-inch and smaller pipe. Ductile Iron Transition Couplings used to join PVC sewer OD pipe to ductile iron OD pipe, shall be PE sewer spigot x DIOD gasket bell or PE DIOD spigot x sewer gasket bell. Adaptors shall be one piece Ductile Iron and conform to the requirements of ASTM D-A-536 grades 65-45-12 or 80-55-06 iron, with a minimum wall thickness equal to or greater than AWWA C-153 pressure class 350 fittings. Adaptor shall be fusion bond epoxy coated inside and out according to AWWA C-116.

E. Ductile Iron Restrained Joint Couplings: Long pattern ductile iron restrained joint couplings may be used when necessary to conform to non-standard existing pipe outside diameters. Gasket sizing shall be as required to conform to the existing pipe outside diameters. Ductile iron couplings may only be used when long pattern solid sleeves will not accept the OD size pipe diameter. Ductile iron couplings shall be designed for a minimum of 350 PSI working pressure and shall be fusion bonded epoxy coated inside and out with a minimum thickness of 12 mils. Bolts, nuts, washers, etc. shall be type 304 or 316 stainless steel. Threads shall be coated with an anti-seize compound.

1. The following ductile iron restrained joint couplings are approved in sizes 1.5-inch through 16-inch diameters:

   a. ROMAC Industries – Standard Alpha Coupling, Alpha XL and Alpha Transition Coupling – 4-inch through 16-inch.

2. Shop drawings shall be required from the manufacturer for 16-inch and larger ductile iron couplings.

2.7 SERVICE CONNECTIONS – TEES AND TAPPING SADDLES

A. New Main Service Connections – Tees and Vertical Bends: All lateral connections to new sewer mains shall be installed using tees and a vertical bend only for connection to new pipe, or shall connect to a manhole. Tapping saddles are not allowed for connections to new mains.

B. Ductile Iron Fittings: All fittings shall be cast from the standard grade 70-50-05 ductile iron with conformance values of 70,000 PSI minimum tensile strength, 50,000 PSI minimum yield strength and 5 percent minimum elongation.

1. 3-inch through 24-inch diameter: minimum Pressure Class 350, cast from ductile iron, in accordance with AWWA C-110 for full body fittings or AWWA C-153 for compact fittings.

2. 30-inch through 48-inch diameter: minimum Pressure Class 250, cast from ductile iron, in accordance with AWWA C-110 for full body fittings or AWWA C-153 for compact fittings.

3. 54-inch through 64-inch diameter: minimum Pressure Class 150, cast from ductile iron, in accordance with AWWA C-110 for full body fittings or AWWA C-153 for compact fittings.

4. All cast fittings shall have a cement mortar lining of standard or double thickness in accordance with AWWA C-104, or fusion bonded epoxy lining and coating of minimum thickness in accordance with AWWA C-116. Ceramic epoxy lining or approved equal shall be required on fittings when specified on a project specific basis.

5. The fittings shall contain all product markings required by AWWA C-110 or C-153 as applicable. The minimum markings on each fitting shall include the identity of the AWWA standard, the pressure rating, nominal diameters, manufacturer's identification, the county where cast, the letters "DI" or "DUCTILE", and the angle of all bends. The markings shall be distinctly cast raised or in relief on the outside of the fitting body.

6. Ductile iron fittings with straight through runs, such as tees, shall have an interior diameter that will allow the standard mandrel diameter to pass through the fitting.

7. Manufacturers:

   a. All fittings, including gaskets, glands, and bolts, shall be furnished by one fittings manufacturer.

   b. 24-inch and smaller fittings shall be manufactured within the North American Continent or imported by an approved manufacturer:

      1) American Cast Iron Pipe Co
      2) U.S. Pipe Co
      3) McWane Cast Iron Pipe
      4) Tyler/Union Foundry
      5) Star Pipe Corporation
      6) Sigma Corporation.
      7) SIP Industries

c. 30-inch and larger fittings shall be manufactured within the North American Continent by an approved manufacturer:

1) American Cast Iron Pipe Co

2) U.S. Pipe Co

3) Griffin Pipe Company

4) McWane Cast Iron Pipe

5) Tyler/Union Foundry

C. PVC Tees in New PVC Sewer Mains: Sewer connections to new PVC sewer mains shall be made with PVC tees.

1. Sewer connections shall be constructed 90° to main (angled connections not permitted) and shall typically be perpendicular to roadway. All connections shall be made substantially as shown on the Standard Details.
2. Connections to the new sewer main shall be made with the appropriate size tees to accommodate the connection and shall be made of C900 DR18 PVC or with DR 26 PVC.

D. Existing Main Service Connections – Tapping Saddles: Sewer tapping saddles for lateral connections, to existing mains, for use on solid or smooth wall pipe shall be ABS Plastic, PVC, Elastomeric PVC, or approved equivalent.

1. Tapping saddles connected to VCP, smooth wall PVC, concrete or ductile iron pipe shall use a fast setting two-part exothermic epoxy sealant that can be used in wet or dry conditions. The tapping saddle shall protrude into the hole, but no part shall protrude into the waterway of the mainline pipe. The saddle shall be of a design that will accommodate AWWA C900 or Ductile Iron lateral pipe with outlet fitting of compression, mechanical or sealing type. The outlet fitting shall not be solvent weld.

a. Manufacturers:

1) Fast Fit Sewer Tap Saddle as manufactured by PREDCO (Plumbing Research Engineering and Development Company), or approved equal.

2. Tapping Saddles on 8-inch through 16-inch Ductile Iron Mains: When ductile iron laterals are to be connected to existing ductile iron or cast-iron sewer mains, the tap on the existing main shall be as follows:

a. Saddles for gravity sewer applications shall have a base that consists of Class 30 Cast Iron conforming to ASTM A-48 and dip-coated in water-based bituminous tar at minimum. Base casting shall have an alignment flange which protrudes into the tapped hole to assure perfect alignment. Adapter accepting DIP shall be made of ductile iron and comply with ASTM A536, Grade 65-45-12 or 80-55-06. Bell depths shall meet the minimum socket depth requirements of ASTM F1336. Adapter gasket grooves shall be machined, and gaskets shall be of SBR rubber and comply with ASTM F477. Saddle strap shall be made from 24-gauge 304 Stainless Steel with a width of 2.5” to support the saddle. Saddle strap pins shall be at least .75” diameter and made from 304 Stainless Steel. T-bolts shall be at least .375” type 304 Stainless Steel. Nuts and Washers shall be at least 18-8 Stainless Steel. Gasketed O-ring shall meet or exceed ASTM C-361-77 Tubular

Polyisoprene. Saddles shall be SEALTITE Type “F” multi-range Tee sewer saddle with alignment flange as manufactured by The General Engineering Company, Frederick, MD, or Romac Style "CB" sewer saddle - CB-4.80 or CB-6.90 or approved equal.

3. Tapping Saddles on 24-inch and Larger Mains: Service connections to 24-inch and larger mains should be connected to manholes only. If CHARLOTTE WATER approves a direct 4-inch or 6-inch connection to the existing pipe, the connection shall consist of a tapping sleeve and vertical ductile iron bend. The tapping sleeve shall comply with the tapping sleeve specifications in the Water Main Specifications but may be a mechanical joint outlet in lieu of a flange outlet. Provide submittal package for review.

4. Sewer Tapping saddles on ductile iron pipe within a 100-foot radius of a well shall be as specified for water main tapping sleeves. A tapping valve is not required. In lieu of the tapping saddle, a ductile iron tee may be installed or cut-in. All pipe including lateral pipe and cleanouts within the 100-foot radius of the well shall be ductile iron as specified.

2.8 MANHOLES

A. Standard Precast Concrete Manholes:

1. All precast manhole sections, and manufacturers shall meet the minimum requirements established by NCDOT for precast manholes in addition to the following CHARLOTTE WATER requirements and standard details. All sewer manholes shall be constructed of precast concrete sections only in conformance with the following specifications and CHARLOTTE WATER Standard Detail Drawings. Special cast in place manhole structures shall be as shown on the plans and shall comply with the various other applicable sections in these specifications.

2. Manholes shall be furnished with pre-cast bottom slabs and flexible watertight boots for 16-inch and smaller pipe. The boots shall be cast in as integral parts of the base or installed in cored openings with stainless steel compression bands and shall conform to ASTM C-923. Manholes for 18-inch and larger pipe may be furnished with precast bottom slabs and flexible boots or flexible seals. Flexible connectors shall conform to ASTM C-923.

   a. Flexible boot and seal manufacturers:

      1) PSX: Direct Drive as manufactured by Press-Seal Corporation

      2) Tylox MIB Series Connectors as manufactured by Hamilton Kent

      3) G3 or QUIK-LOK Boot Connectors as manufactured by A-LOK Products, Inc.

      4) Manhole boots used in manholes greater than 30 feet deep shall be Kor-N-Seal High Pressure Series as manufactured by NPC Corporation, or approved equal.

   b. Manhole diameters may be controlled by the boot or seal diameters. A minimum of 6-inches of manhole wall shall be provided between cored or cast pipe openings for pipe connections, or as may be required by the boot/seal manufacturer, whichever is greater.

3. Manholes to be placed over existing pipelines shall be furnished with straddle/doghouse openings in the precast manhole bottom section allowing the manhole to be set over existing pipes in accordance with the Standard Details.

4. Sections: All precast reinforced concrete manholes shall conform to CHARLOTTE WATER Standard Detail drawings and to ASTM C-478. The following minimum standards shall also apply:

   a. Wall thickness shall be 1/12th of the inside diameter with a minimum thickness of five (5) inches. Top of cone sections shall have a minimum wall thickness of 8 inches.

   b. Base sections shall be cast monolithically and shall NOT have a cold joint between the walls and the base slab.

   c. Cone sections shall normally be eccentric with the inside face of one side vertical and flush with the inside face of the barrel section. 4-foot diameter eccentric cones shall have a minimum vertical height, as measured from the top of the cone to the bottom of the bell, of 32 inches. Eccentric cones with a minimum vertical height of 40-inches shall be required for 5' diameter manholes. The sloped wall of the cone section shall be the full required cone height. Cone sections taller than the required cone height may include a vertical wall skirt below the required cone height. Concentric cones with a vertical height of 20-inches may be used on manholes less than five (5) feet deep (4-ft diameter manhole only).

   d. Transition slabs may be placed a minimum of six (6) feet above the invert shelf for six (6) feet and larger diameter manholes where the slab will be buried. Flat top slabs directly below the frame and cover may be used for six (6) feet and larger diameter manholes, unless the manhole is located within pavement or maintained lawns. Flat top slabs require a minimum of six (6) feet above the invert shelf.

   e. Joints between sections shall be manufactured in accordance with ASTM C-443. Joints shall be sealed with two rings of butyl rubber sealants conforming to ASTM C-990. A primer adhesive shall be used when recommended by the sealant manufacturer.

   f. Butyl rubber joint sealants shall meet or exceed the requirements of ASTM C-990 including the 10 PSI hydrostatic test requirement.

      1) Butyl rubber joint sealant manufacturers:

         a) Butyl-Tite by MultiSeal

         b) Butyl-Loc by A-Lok Products, Inc.

         c) EZ-Stik Sealant by Press Seal Gasket Corporation,

         d) CS102 or CS202 by ConSeal Concrete Sealants, Inc.

         e) HK Kent Seal No.2 by Hamilton Kent, Inc.

         f) Or, approved equal

   g. All exterior joints (including base and riser sections) shall be sealed with one 6-inch wide (minimum) exterior butyl rubber joint sealant membrane centered on the joint. The tape shall be capable of sealing manhole joints against

groundwater and sand infiltration. Exterior Joint Wrap sealant with rubber or plastic backing shall meet or exceed the requirements of ASTM C-877 Type III and C-990. Joint wrap shall be a minimum of 6 inches wide and not less than 1.5 times the joint depth. The butyl component of the joint wrap shall be a minimum of 0.030-inchs (3 mils) thick. The rubber or plastic backing material shall be a minimum of 0.040-inches (4 mils) thick. The installation of the joint sealant membrane shall be in conformance with the recommendations of the manufacturer. A primer/adhesive shall be used when recommended by the sealant manufacturer.

1) Exterior joint wrap manufacturers:

a) EZ-Wrap by Press-Seal Gasket Corporation

b) CS-212 by ConSeal Concrete Sealants, Inc.

c) Butyl-Tite Wrap by MultiSeal

d) Bidco Wrap by NPC Corporation

e) Or, approved equal

h. All markings required by ASTM C-478 shall be clearly stamped on interior and exterior of each section. The minimum markings on each section shall include manufacturer's name or trademark, date of manufacture, and specification and product designation. Each manhole section installed in existing or future NCDOT right-of-way shall contain all approval markings required by and/or furnished by NCDOT.

i. Aggregate shall conform to requirements of ASTM C-33. Flat or elongated aggregate or smooth round stones shall NOT be acceptable.

j. The hydraulic cement used shall be Portland cement meeting requirements of ASTM C-150 Type II or Portland-limestone cement meeting ASTM C-595 Type IL(MS). Type II shall have a maximum tricalcium aluminate (content 8%).

k. Manhole base sections, riser sections, transition slabs, flat top slabs, and cone sections shall be designed for H-20 loadings, and a minimum manhole height of 40 feet. Earth loading shall be 120 pounds per cubic foot. Flat top slabs shall be designed for a minimum of 3 feet of earth loading.

l. The manufacturer shall furnish the Engineer with test results on compression and absorption for one section in every twenty-five sections poured, and certification from cement manufacturer and aggregate supplier certifying chemical content. The Engineer reserves the right to pick random sections for the required testing. Manufacturer's with NCDOT approved labs may self-perform the required daily tests. At least one set of tests each month shall be performed by an independent testing facility. Manufacturer's without NCDOT approved labs shall use an independent testing facility for daily tests. All test results shall be submitted to CHARLOTTE WATER.

m. Precast products shall not be shipped from the manufacturer until it has reached a minimum of 4000 PSI compressive strength, and no less than 7 days after casting, whichever is greater.

5. Steps

   a. Manhole steps will be furnished in accordance with the Standard Details, ASTM C-478 and current OSHA regulations. In addition to the testing requirements of ASTM C-478 each step installed in pre-cast manholes will be tested to resist a 1000 lb pullout. The manhole manufacturer will furnish test report results for step test with each shipment showing manhole location, date of test, and results. Each step installed in the field shall be tested as specified above. All step test results shall be submitted to CHARLOTTE WATER.

   b. Plastic of manhole steps shall meet the requirements of ASTM D-4101. Steel reinforcing bar shall be Grade 60 deformed ½-inch diameter rebar conforming to the requirements of ASTM A-615.

   c. Manhole step manufacturers:

      1) MA Industries, Inc.

      2) BOWCO Industries, Inc.

      3) American Step Company, Inc.

      4) Or, approved equal

6. Liner: Where indicated on the plans or elsewhere in these specifications, precast concrete manholes shall be furnished with a cementitious liner in accordance with these specifications for resistance to corrosive sewers.

7. Manholes shall be manufactured by manhole manufacturer's which have been approved by NCDOT and CHARLOTTE WATER to provide precast manhole product. New firms requesting approval to supply product to CHARLOTTE WATER projects, must provide approval letters from NCDOT for each product line, prior to requesting approval from CHARLOTTE WATER.

8. Required submittals for product approval include, but are not limited to, product brochure, catalog cuts or shop drawings including dimensions and part/material list, design calculations, concrete mix design, cement certification, aggregate analysis, certification of compliance, prior product acceptance test reports, and reference contact data. Sample products shall be inspected by CHARLOTTE WATER at the manufacturing plant and/or previously installed product. Manhole shop drawings and design calculations shall be signed and sealed by a North Carolina Professional Engineer.

9. Required daily and monthly test reports/results shall be submitted to the CHARLOTTE WATER Material's and Methods Committee Chair. Failure to provide required test results shall result in removal of the manufacturer from the approved manufacturer's list. Test results for projects advertised and bid directly by CHARLOTTE WATER, shall be sent directly to the attention of the CHARLOTTE WATER Project Manager.

10. The following manhole manufacturers are approved to supply manhole products for inclusion into the CHARLOTTE WATER system as indicated by manhole diameter:

MANUFACTURER	MANHOLE DIAMETERS APPROVED				
	4-FT	5-FT	6-FT	8-FT	10-FT
Tindall Corp.	X	X	X	X	X
CP&P Denver – Formerly Dellinger Precast	X	X	X		
CP&P Concord – Formerly Precast Supply Co.	X	X	X	X	
Performance Precast, Inc.	X	X			

11. This list was current at the time of publication. Be aware that these manufacturers produce some products that conform to these specifications, and also produce some products that do not conform to the specifications. Project approval will be based on shop drawing review and approval. Approved manufacturers and approved product sizes are subject to change, based on compliance with the specifications, quality control, acceptance test reporting and NCDOT approval.

B. Polymer Concrete Manholes:

1. General: All precast manhole sections, and manufacturers shall meet the minimum requirements established by NCDOT for precast manholes in addition to the following CHARLOTTE WATER requirements and standard details. All sewer manholes shall be constructed of precast concrete sections only in conformance with the following specifications and CHARLOTTE WATER Standard Detail Drawings. Special cast in place manhole structures shall be as shown on the plans and shall comply with the various other applicable sections in these specifications.

   a. The polymer concrete manhole shall be as manufactured by Armorock, Boulder City, Nevada; US Composite Pipe Inc., Alvarado, TX; or pre-approved equal.

   b. Reference to a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

   c. Like items of materials/equipment shall be the end products of one manufacturer in order to provide standardization for appearance, operation, maintenance, spare parts and manufacturer's service.

   d. Provide engineered non-penetrating lifting devices in each precast section for proper handling.

   e. Cement for base slabs and anti-flotation slabs/collars shall conform to ASTM C150, Type II cement or equal.

   f. Mark date of manufacture, name and trademark of manufacturer on inside and outside of each precast section.

   g. Brick masonry shall not be utilized for any part of the polymer concrete manhole.

2. Polymer Concrete Structure Sections

   a. Precast concrete base sections, riser sections, transition top sections, flat slab tops and grade rings shall conform to ASTM C478 and meet the following requirements:

1) Structures shall be designed for all live and dead loads in accordance with ASTM C890 including a live load equal to AASHTO H-20 truck loading applied at finished grade with a minimum manhole height of 40 vertical feet.

2) Base, riser and top sections shall have bell and spigot/ship-lap design so that, on assembly, the manhole base, riser and top section make a continuous uniform manhole.

3) Top section shall be eccentric cone where cover over pipe exceeds 4-ft. Top section shall be a flat slab where cover over top of pipe is 4-ft or less. Top section shall meet the requirements of the general requirements of the concrete manhole specifications above and the standard details unless otherwise approved by CHARLOTTE WATER.

3. Design

a. Structure walls, transition slabs, tops, and base slab shall be designed according to the requirements of ASTM C478, and C890. FRP (fiber-reinforced polymer) reinforced products shall be designed according to ACI 440.1R.

b. Design loading requirements:

1) AASHTO M-306 H-20/HS-20 design live loading loads as referred to in AASHTO M-305 applied to manhole cover or structure top slab and transmitted down to transition and base slabs.

2) Manhole design loading requirements shall be for a minimum vertical height of 40 feet.

3) Unit weight of soil of 120 pcf located above portions of structure, including base slab projections.

4) Lateral soil pressure based on saturated soil conditions producing an at rest equivalent fluid pressure of 100 psf.

5) Internal liquid pressure based on unit weight of 63 pcf.

6) Dead load of manhole sections fully supported by transition and base slabs.

c. Structure wall thickness shall be designed to resist hydrostatic pressures with a minimum factor of safety of 2.0 for full depth conditions from grade to invert. The manufacturer shall assume the design groundwater level is at finished grade. Wall thickness shall be a minimum of 3” for 48” and 60” manholes and 4” for 72”, 84”, and 96” manholes.

d. Structure shall be designed with sufficient bottom anchorage and side friction to resist buoyancy with a minimum factor of safety of 2.0. Field cast floatation collars are acceptable. The manufacturer shall assume the design groundwater level is at finished grade and the structure is empty.

e. For manholes with a minimum vertical height of 40 feet, the minimum clear distance between pipe openings shall be 6” or half the diameter of the smaller opening, whichever is greater.

f. For manholes with a minimum vertical height of 40 feet, the minimum clear distance between an opening and a joint shall be 6”.

g. Structure shall have a monolithic base slab unless otherwise approved. Monolithic base sections shall have vertical reinforcing extend into the base slab section.

h. Structures shall be designed with the reinforcement carrying all of the tensile stress. The tensile property of the polymer concrete shall not be used in the design calculations.

4. Polymer Concrete

a. Resin:

1) The resin shall be polyester or vinyl ester resin systems designed for use with this particular application.

2) The resin content shall be a minimum of 7% by weight.

3) The resin shall have a minimum deflection temperature of 158 F when tested at 264 psi following test method in accordance with ASTM D648.

4) The resin selection shall be suitable for application in the corrosive conditions in a wastewater manhole.

b. Filler: All aggregate, sand and quartz powder shall meet the requirements of ASTM C33.

c. Additives: Resin additives such as curing agents, pigments, dyes, fillers and thixotropic agents, when used, shall not be detrimental to the manhole.

d. Polymer concrete compressive strength shall be a minimum of 9000 psi per ASTM C497.

e. No Portland cement shall be permitted in the polymer concrete mix and all aggregates shall have a minimum acid insoluble content of 95%.

5. Reinforcement

a. Deformed Steel Reinforcing Bars: ASTM A615, Grade 60 deformed bars.

b. Deformed Fiberglass Reinforced Polymer Bars (FRP): ACI 440.1R-06, “Guide for Design & Construction of Structural Concrete Reinforced with FRP Bars”.

c. Reinforcing shall be in accordance with ASTM C478. If FRP reinforcement is used, reinforcement shall be placed according to ASTM C478 for barrel sections and slabs. Required ASTM C478 steel area shall be converted to equivalent FRP design per ACI 440.1R. Hoop reinforcement shall only be permitted per ASTM C478.

d. Steel Welded Wire Reinforcement: ASTM A497.

6. Joints

a. Structure components shall be connected with an elastomeric sealing gasket as the sole means to maintain joint water tightness and both the gasket material and the manhole joint shall meet the requirements of ASTM C443.

b. Structure shall utilize spigot and bell type joints incorporating either a confined O-ring or single step profile joint.

c. Joints shall be sealed with two rings of butyl rubber sealants conforming to ASTM C-990. A primer adhesive shall be used when recommended by the sealant manufacturer.

7. Pipe Connections

a. Provide resilient connectors conforming to the requirements of ASTM C923. Certification from connector manufacturer shall be provided if requested. Resilient connectors shall be installed directly to the monolithic structure wall or cast in during the initial pour. Cold joint pipe stub grouting shall not be allowed to facilitate connectors unless specifically indicated on the plans. Use the following materials for metallic mechanical devices as defined in ASTM C923:

1) External clamps: Type 304 Stainless steel

2) Internal, expandable clamps: Type 304 stainless steel, 11gauge minimum.

b. All connectors are to be watertight.

c. Where penetrations of pre-fabricated polymer concrete structures are required for piping, conduit, or ducts, such penetrations shall be through precast openings. All openings shall be smooth and free of surface irregularities and with exposed steel reinforcing. A separate opening shall be provided for each pipe or conduit entering the structure.

8. Vent Pipe

a. Vent pipes shall be constructed of steel pipe as shown on the Standard Details.

9. Ladders for Polymer Concrete Manholes

a. Access to polymer concrete manholes should be via a field installed polypropylene vault ladder.

b. Polypropylene shall conform to ASTM D-4101.

c. Ladder shall meet all ASTM C-497 load requirements as well as OSHA 1910.26 and 1910.27 specifications.

d. Ladders shall meet a minimum of 1,500 lbs pull out force.

e. Ladder rails shall be aluminum reinforced copolymer polypropylene 1-3/4” x 1-3/4” diameter.

f. Ladder rungs shall be steel reinforced copolymer polypropylene 1-5/8” x 1-1/4” diameter with molded finger grips 12” c.c.

10. Manholes shall be manufactured by manhole manufacturer’s which have been approved by NCDOT and CHARLOTTE WATER to provide precast manhole product. New firms requesting approval to supply product to CHARLOTTE WATER projects, must provide approval letters from NCDOT for each product line, prior to requesting approval from CHARLOTTE WATER. Manhole shop drawings and design calculations shall be signed and sealed by a North Carolina Professional Engineer.

11. Required submittals for product approval include, but are not limited to, product brochure, catalog cuts or shop drawings including dimensions and part/material list,

design calculations, polymer concrete mix design, polymer certification, aggregate analysis, certification of compliance, prior product acceptance test reports, and reference contact data. Sample products shall be inspected by CHARLOTTE WATER at the manufacturing plant and/or previously installed product.

12. Required daily and monthly test reports/results shall be submitted to the CHARLOTTE WATER Material's and Methods Committee Chair. Failure to provide required test results shall result in removal of the manufacturer from the approved manufacturer's list. Test results for projects advertised and bid directly by CHARLOTTE WATER, shall be sent directly to the attention of the CHARLOTTE WATER Project Manager.

C. Manhole Frames and Covers:

1. Cast Iron Castings

a. Frames, Covers, And Grates: All manhole frames and covers shall conform to ASTM A-48, Class 35 and shall be manufactured in domestic foundries as allowable. Dimensions and minimum weight shall conform to the CHARLOTTE WATER Standard Details.

b. Manhole frames and covers shall be furnished with the common contact surfaces between frame and cover machined. Frames and covers shall be U.S. Foundry & Manufacturing Corp, EJ Group, Inc., or pre-approved equal.

c. Where watertight frames and covers are specified, the watertight seal between frame and cover shall be accomplished by means of a rubber gasket, and a camlock bolt down locking system. Watertight frames and covers shall be U.S. Foundry & Manufacturing Corp, EJ Group, Inc., or pre-approved equal.

d. Smart Covers and Frames

1) The smart cover system shall include an e-box, distance sensing module, power source, antenna, and 316 stainless steel mounting hardware.

2) The e-box shall have a tilt detection angle of 10° ±3° and have external connectors for the antenna, power source, and sensor.

3) The distance sensing module shall be a dual sensor capable of sensing via both ultrasonic and pressure. The distance sensing module shall be free hanging and have a total dynamic range of 40 feet.

a) The standard system timing shall obtain a level measurement once every 5 minutes and record the level data once every 10 minutes.

4) The power source shall be a 3.6 VDC power pack and have a standard operating lifetime of two years.

5) The smart cover system shall communicate two-way (transmit and receive) with a low-earth-orbit satellite with global coverage. The communications system shall operate on a radio frequency from 1616 to 1626.5 MHz with a typical latency ranging from 10 seconds to 10 minutes. The antenna shall be traffic compatible and weatherproof.

a) The system shall have a data transmission reporting interval of 1 hour and a status reporting interval of 14 hours.

6) The smart cover system shall be capable of operating in temperatures from 14°F to 140 °F and humidity from 0% to 100% RH.

7) The smart cover system shall have an application programming interface designed to provide programmatic access to data with location list, location summary, historical data, alarm list, alert list, token refresh, and latest data capabilities.

8) Manufacturers

a) SmartCover

b) SUEZ in North America

c) X-Logic

d) Accuflo

2. Composites - Frames and Covers

a. Clear openings, general dimensions, markings, accessories, etc., and installation shall conform to the CHARLOTTE WATER Standard Details for castings.

b. From fiber reinforced polymer following AASHTO M306.

c. Composite manhole covers shall meet the AASHTO H20 loading requirements.

d. Frame shall be set with four (4) quarter turn locks and water-resistant secondary o-ring gaskets.

e. All lock components shall be manufactured using a 300-grade stainless steel.

f. Manufacturers

1) EJCO

2) Trumbull Manufacturing, Inc

3) Enviro Design Products

g. Shop drawing submittal packages are required for review and preapproval by the CHARLOTTE WATER materials and methods committee.

D. Grade Rings: Grade rings may be concrete, rubber, or expanded polypropylene adjustment grade ring-flat or with taper for slope adjustment. All brick and mortar used to adjust frames shall be in accordance with materials defined in Part 2, Products, of these technical specifications.

1. Concrete Grade Rings: All concrete grade rings shall conform to ASTM C478 and AASHTO M 199. Concrete grade rings shall have two rings of rebar near inner and outer face and a minimum width of 8-inches. Concrete grade ring manufacturers shall be as defined in Part 2.7.A.10, Products (approved concrete manhole manufacturers), or pre-approved equal. Minimum grade ring height shall be 2 inches and maximum grade ring height shall be 8 inches. Steel reinforcements

shall be a minimum of 0.07 sq. inches per vertical but not less than 0.024 sq. inches in any one grade ring. Any cracks shall result in rejection of the grade ring.

2. Rubber Grade Rings: All rubber grade rings shall conform to ASTM D3574-05 Test A, ASTM D2240-05, ASTM D412-06, and ASTM D573-04 and have a minimum width of 6-inches. Rubber grade rings shall be EJ Group, Inc. Infra-Riser, American Highway Products Flex-ORing, or pre-approved equal. Height of flat rings shall be from 0.50 inches to 3.0 inches in 0.50-inch increments. Taper/angle ring heights shall be a minimum of 0.50 inches and a maximum height of 3.0 inches. The maximum height of rubber rings on a manhole shall be 8 inches. Any additional height must be made up with concrete grade rings.

3. Expanded Polypropylene (EPP) Grade Rings: All EPP grade rings shall conform to ASTM D4819-13 and AASHTO M 306 and have a minimum width of 6-inches. EPP grade rings shall be Cretex Pro-Ring, ARPRO, or pre-approved equal. Height of flat rings shall be from 0.75 inches to 4.0 inches in 0.50-inch increments. Taper/angle ring heights shall be a minimum of 0.75 inches and a maximum height of 1.75 inches. The maximum height of EPP rings on a manhole shall be 8 inches, any additional height must be made up with concrete grade rings.

4. Ring Adhesives:

   a. For Rubber Grade Rings: Adhesive between rings shall be a butyl rubber sealant conforming to ASTM C-990 and AASHTO M-198.

   b. For Expanded Polypropylene (EPP) Grade Rings: For Cretex Pro-Ring, adhesive shall be M-1 type. Refer to manufacturer's recommended ring adhesive for pre-approved EPP equal.

2.9 PARSHALL FLUMES

A. Configuration

1. Size: As indicated on the construction drawings.

2. The manhole height shall be as measured from:

   a. Dome top manholes:

      1) Inlet invert to surface grade plus 12 inches

B. Construction

1. One-piece construction with integral inlet and outlet end connections.

C. Materials

1. Fiberglass reinforced plastic, complying with ASTM D 3753, latest edition.

2. Factory-assembled, ready for installation except for field-installed equipment.

3. The exterior surface shall be relatively smooth with no sharp projections. The surface shall be free of blisters larger than 1/2 inch in diameter, delamination and fiber show.

4. The interior surfaces shall be resin rich and unpigmented to allow for visual inspection of the manhole laminate. There shall be no exposed fibers. Additionally, the interior surface shall be smooth for improved corrosion resistance and reduced

sludge build-up. The surface shall be free of crazing, delamination, blisters larger than 1/2 inch in diameter, and wrinkles of 1/8 inch or greater in depth.

5. Minimum 1/2-inch wall thickness.

6. Integral fiberglass ladder bolted and glassed to the manhole wall with 1-1/2 inch diameter pultruded fiberglass rungs with a photoluminescent high visibility non-slip top surface and reinforced with threaded T-304 5/16-inch diameter stainless steel rods and solid 1-1/4 inch diameter pultruded fiberglass spacers.

7. Inlet and outlet end connections molded to the flume and laminated to the manhole barrel. The end connections shall be provided with:

    a. PVC or fiberglass pipe stubs with flexible rubber boots and stainless steel bands.

8. A 3/4-inch-thick expanded polystyrene bead board shall be supplied to place under the manhole on the concrete slab.

9. A 4-inch wide FRP integral mounting flange shall be molded to the base of the manhole barrel for anchoring to the manhole to the concrete slab.

10. An OSHA approved “Confined Space Entry” sign shall be applied to the interior surface of the manhole above the first ladder rung (H-20 type) or on the underside of the manhole top (dome top and aluminum hatch types).

11. One (1) 2-inch NPT coupling to facilitate the installation of sample or bubble tubing, electrical power, or other cabling into the manhole. Run sample lines and electrical lines in separate conduits or cross-talk may occur across unshielded electrical lines.

12. The resins used shall be unsaturated, supplier certified, isophthalic polyester resins. Mixing lots of resin from different manufacturers or “odd-lotting” of resins shall not be permitted. Quality assurance records on the resin shall be maintained.

13. The manhole interior shall be provided with a resin rich, corrosion resistant interior surface. The interior surface shall be unpigmented to allow for visual inspection for voids, inclusions, and defects as well as for verification that “odd-lotting” has not occurred.

14. 15 mil isophatlic U.V. resistant gel coat on all exterior surfaces.

15. Reinforcing materials shall be high performance commercial grade with a coupling agent that will provide a suitable bond between the glass reinforcement and the resin.

16. The manhole laminate shall consist of multiple layers of glass matting and resin. The surface exposed to the sewer / chemical environment shall be resin rich and shall have no exposed fibers.

17. The flume laminate shall be a minimum of 3/16 thick with a 15 mil isophthalic U.V. resistant gel coat, with those portions of the flume extending outside the manhole sufficiently thickened and reinforced as necessary to withstand the forces of the intended application.

D. Materials Properties

1. Manhole Barrel and Reducer:

    a. Flexural strength (ASTM D790):

1) 15,400 PSI (reducer - hoop).
2) 17,200 PSI (reducer - axial).
3) 22,500 PSI (reducer - hoop).
4) 14,300 PSI (reducer - axial).

b. Compressive Strength (ASTM D695):

1) 18,900 PSI (barrel).

c. Barrel Stiffness (ASTM D2412):

1)	Manhole Length: 3-6 ft	PSI:	0.72
2)	Manhole Length: 7-12 ft	PSI:	1.26
3)	Manhole Length: 13-20 ft	PSI:	2.01
4)	Manhole Length: 21-25 ft	PSI:	3.02
5)	Manhole Length: 26-35 ft	PSI:	5.24

2. Flume:

a.	Tensile strength (ASTM D 638):	14,000 PSI.
b.	Flexural strength (ASTM D 790):	27,000 PSI.
c.	Flexural modulus (ASTM D 790):	1,000,000 PSI.
d.	Barcol hardness (ASTM D 2583):	50.

E. Top Style

1. Dome Top:

a. A fully opening dome top cover rated for 1,000 lb. static top load with a solid FRP hinge block, neoprene gasket for sealing, and stainless steel hardware (consisting of a piano hinge, lockable hasp, and cover support bar with locking pin on a retaining chain).

F. Flume And Measurement Options

1. Molded-in, high visibility staff gauge, Graduated in 1/10 foot and 1/100 foot increments.

2. Ultrasonic mounting bracket, vertically adjustable, over-channel, 304 stainless steel.

G. Manufacturers

1. The product shall be manufactured by TRACOM, Inc.; 6575-A Industrial Way, Alpharetta, Georgia 30004; Toll-Free Voice (877) 435-8637, Toll-Free Fax (866) 435-8637, www.tracomfrp.com., or approved equal.

2. Requests for substitution must be made in writing and received by the Engineer's office a minimum of ten (10) business days before bid opening.

3. Substitutions: Manufacturers not pre-approved shall not be allowed.

4. Fiberglass tanks modified for flume installation shall not be allowed.

5. Warranty: Manholes shall be warranted to be free of defects in workmanship and materials for a period of (2) two years from shipment.

2.10 CONCRETE

A. Portland Cement: All concrete shall conform to the Standard Specifications for READY MIXED CONCRETE, ASTM C-94. An air-entraining admixture, conforming to ASTM C-260, shall be added to either Type II or Type III Portland Cement. Fly Ash conforming to ASTM C-618 for Class F Fly Ash may be added to the concrete mix but shall not be considered as replacement for more than 25% of the cement therein (strengths shall not be less than hereinafter required). Type IL Portland-limestone cement, meeting ASTM C-595, shall be allowed in lieu of Type II Portland-cement.

1. Types III and IIIA Portland Cement shall only be used for manhole inverts, concrete encasement, concrete blocking, and/or as directed by the Engineer and shall conform to ASTM C-150.

2. Types II and IIA Portland Cement shall be used in precast manholes, cast in place structures, reinforced concrete piers and concrete as directed by the Engineer, and shall conform to ASTM C-150 except that Tricalcium Aluminate content shall not exceed 8%. Portland-limestone cement Type IL(MS), conforming to ASTM C-595, shall be allowed in lieu of Types II and IIA.

B. Aggregates: All aggregates used for concreting shall conform to ASTM C-33 and shall be checked daily for any variances in moisture content. Said variances shall be corrected and/or taken into consideration for each batch.

1. Coarse Aggregates: Shall be uniformly and evenly graded for each application in accordance with A.C.I. Standard 318. Unless otherwise approved, aggregate shall be sound, crushed, angular granitic stone. Flat or elongated aggregate or smooth round stones shall not be acceptable.

2. Fine Aggregates: Shall consist of natural sand, manufactured sand or a combination thereof. Fine aggregates shall conform to the sieve analysis as specified in paragraph 4.1 of ASTM C-33 except that the percent passing a No. 50 sieve shall not exceed 5% and the percent passing a No. 100 sieve shall be 0% as provided for in paragraph 4.2 of ASTM C-33.

C. Mix Design: Concrete shall be watertight, resistant to freeze-thaw cycles and moderate sulfate attack, abrasion resistant, workable, and/or finishable. These qualities may be met through the use of admixtures (if and only if approved in the mix design as hereinafter specified) conforming to the appropriate ASTM with the exception of the use of calcium chloride, which shall be limited to no more than 1% by cement weight - thoroughly mixed to insure uniform distribution within the mix. If the concrete is used with reinforcing steel, no calcium chloride will be allowed. The Contractor shall assume responsibility for concrete mixture. When required by the Engineer, and prior to beginning construction, the Contractor, at their expense, shall obtain from an approved commercial testing laboratory a design for a suitable concrete mix and submit same with their list of materials and material suppliers for approval. The concrete shall be proportioned to meet the following requirements: (Note: This mix does not apply "in total" to precast manholes).

1. Compressive Strength: Minimum 3,600 psi

2. Water-Cement Ratio By Weight: Maximum 0.50

3. Slump: Minimum 3”, Maximum 5”

4. Superplasticizer Slump: 6” – 8”

5. Air Content (Entrained and Entrapped): Minimum 4%, Maximum 6%

6. Coarse Aggregate: ¾” - 1 ½” (as required by the application)

D. Superplasticizer: When superplasticizers are specified or allowed provide in accordance with ASTM C494, Types F & G, with a slump in excess of 7.5 inches.

E. Curing Compound: All concrete curing compounds shall conform to the standard specifications for LIQUID MEMBRANE - FORMING COMPOUNDS FOR CURING CONCRETE, ASTM C-309, Type 2. Curing compounds shall be applied if forms are stripped when concrete is to remain exposed to atmosphere.

F. Grouts: All grouts shall be of a non-shrink nature (as may be achieved through additives or proportioning) and depending upon application range from plastic to flowable cement water paste. Testing as specified above for concrete may be required for acceptance of grouts to include frequent checks for consistency by a time-of-flow measurement. Expansion grouts shall be either MasterFlow 648 epoxy grout by BASF, or 1428HP Grout by W.R. Meadows, or approved equal. Grouts shall be mixed (if applicable) and placed in accordance with the manufacturer's current recommendations, for each specific application. Expansion grouts shall be used only as directed by the Engineer. Acceptable range of testing requirements:

1. Compressive Strength: 10,500 psi to 12,500 psi.

2. Bond Strength: 1,350 psi to 1,700 psi.

3. Percent Expansion: + 0.025% to + 0.75%

G. Mortar: Mortar used in sanitary sewer manholes shall be hydraulic cement mortar in accordance with ASTM C-398. Mortar used in sewer manholes shall be Type M mortar in accordance with ASTM C-270.

H. Flowable/Excavatable Fill (CLSM): Contractor shall furnish and place flowable fill i.e. controlled low strength material (CLSM) backfill where shown in the drawings.

1. Cement: All cement used shall be Type II Portland cement which shall conform to the requirements of ASTM C150.

2. Fly Ash: ASTM C618, Class F.

3. Aggregates: Fine aggregate shall conform to the grading and quality requirements of ASTM C33. Coarse aggregate shall conform to the grading and quality requirements of ASTM C33 for size No. 476, No. 57, or No. 67.

4. Water: The batch mixing water and mixer washout water shall conform to the requirements of ASTM C94.

5. Flowable Fill Properties:

   a. CLSM shall have a maximum fifty-six (56) day compressive strength of one hundred (150) psi when molded and cured as in conformance with ASTM D4832.

   b. CLSM shall have a minimum cement content of fifty (50) pounds per cubic yard. The water-cementitious materials ratio of the mix shall not exceed three and one-half to one (3.5:1).

c. CLSM shall be air entrained to a total air content of approximately five percent (5%).

d. The minimum slump shall be six (6) inches and the maximum slump shall be eight (8) inches when tested in accordance with ASTM D6103.

e. Fine aggregate shall be between fifty percent (50%) and sixty percent (60%) by volume of the total aggregates in the CLSM mix.

f. The consistency of the CLSM slurry shall be such that the material flows easily into all openings between the pipe and the lower portion of the trench. When trenches are on a steep slope, a stiffer mix of slurry may be required to prevent CLSM from flowing down the trench. When a stiffer mix is used, vibration shall be performed to ensure that the CLSM slurry completely fills all spaces between the pipe and the lower portion of the trench.

I. Lightweight Cellular Concrete Fill – For Use In Annular Spaces Inside Casing Pipe and Tunnel Pipes. See Chapter 21 “Tunneling and Encasement” of the CHARLOTTE WATER Standards.

2.11 MISCELLANEOUS STEEL

A. General: This section contains general product specifications for miscellaneous steel components. See project drawings for project specific requirements, and/or CHARLOTTE WATER’s Standard Details.

B. Steel Pier Material:

1. All steel pier material shall be hot dipped galvanized and coated in accordance with these specifications.

2. Steel piles, cross braces, cradles, etc., shall consist of structural steel shapes of the section required on the Plans and Details. The steel shall conform to Specifications For Steel For Bridges And Buildings, ASTM A-36.

3. All bolts and nuts will conform to ASTM A-325 for 7/8-inch and to ASTM A-490 for 1- inch and larger.

4. The Contractor shall handle and store steel members above ground on platforms, skids, or other supports. Members shall be free of dirt, grease, and other foreign material and protected against corrosion.

5. Welding Electrodes shall conform to the following:

a. Shielded Metal-Arc: AWS A5.1 or AWS 5.5, E70XX

b. Submerged-Arc: AWS A5.17, F70X-EXXX

c. Gas Metal-Arc: AWS A5.18, E70S-X or E70U-1

d. Flux Cored-Arc: AWS A5.20, E70T-X (except 2 and 3)

C. Steel Vent Pipe

1. Steel Vent Pipe: Unless otherwise specified, steel vents shall be Schedule 40 5-inch diameter steel pipe, consisting of Grade "B" steel as specified in ASTM A-139, with ANSI Class 150 flange end outlet.

2. All steel shall be Grade "B" only, with a minimum yield strength of 35,000 P.S.I.

3. Pipe design shall be in accordance with AWWA M11 considering the following:

a. Internal pressure

b. External pressure

c. Special physical loading

d. Practical requirements

e. Minimum wall thickness of 0.25 inch

4. The steel pipe shall have an inside lining - minimum 20 mils dry film thickness of Tnemec Perma-Shield PL Series 431, or approved equal, or shall have fusion-bonded epoxy coating in accordance with AWWA C213. Surface preparation and supplication shall be as recommended by Tnemec or approved equal manufacturer. Lining applicator shall be a Tnemec approved certified applicator or approved equal manufacturer's approved certified applicator.

5. Outside surface of the pipe exterior coating shall be fusion-bonded epoxy coating in accordance with AWWA C213 as per Tnemec or approved equal. Surface preparation and application shall be as recommended by Tnemec or approved equal. The coating applicator shall be a Tnemec or approved equal certified applicator.

   a. Exterior coating shall be forest green or olive green, as approved by the Engineer.

6. Vent pipe shall be equipped with a screen to guard from insects, debris, and animals as indicated on the Standard Details. Screen shall be sized to fit and installed securely inside the hub or coupling of the vent pipe. Screen shall be constructed of 0.009" thick 316 stainless steel 18 x 18 mesh with 0.047" openings.

D. Anchors

1. Including uses for, but not limited to, the following:

   a. Hardware for vertical manhole frame and cover adjustments

2. Anchors: All frame anchors, bolts and washers shall conform to the requirements of ASTM A-36 with a minimum yield strength of 36,000 P.S.I. All anchor components shall be hot dip galvanized as specified below. Including uses for, but not limited to, the following:

   a. Manhole frame and cover anchorage.

E. Stainless Steel Straps and Anchors

1. Including uses for, but not limited to, the following:

   a. Piping for inside and outside drops for manholes

   b. Reinforced concrete piers

   c. Service lateral connections to CIPP

   d. Precast manhole vents

2. Straps for concrete piers, manhole vent pipes, inside drops, and outside drops: Stainless Steel ASTM A240 Type 304 or Type 304L.

3. For stainless steel anchors, bolts, and washers (hardware): Stainless Steel ASTM A240 Type 316 or Type 316L.

4. Epoxy Adhesive Anchorage: Adhesive anchors shall consist of a two-component structural epoxy injection gel meeting the requirements of ASTM C881, stainless steel screen tubes of hollow base materials. Minimum adhesive anchor embedment shall be 4-inches (5-inches minimum for frame and cover) unless otherwise indicated. Provide epoxy adhesive anchors by Hilti Corporation HIT-HY 200, ITW Red Head A7+ Quick-Dure Adhesive, Powers Fasteners Pure 150-Pro Epoxy, or pre-approved equal.

   a. Cartridge Injection Adhesive Anchors

      1) Threaded steel rod, inserts or reinforcing dowels, complete with nuts, washers, polymer or hybrid mortar adhesive injection system, and manufacturer's installation instructions. Type and size as indicated on the Standard Details.

      2) Interior and Exterior Use: As indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. All nuts shall conform to ASTM F594 unless otherwise specified.

      3) When indicated on the project drawings, or specified by the Standard Details, deformed reinforcing dowels shall be A615 Grade 60.

   b. Capsule Anchors

      1) Threaded steel rod, inserts and deformed reinforcing dowels with 45-degree chisel point, complete with nuts, washers, glass or foil capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, and manufacturer's installation instructions. Type and size as indicated on the Standard Details.

      2) Interior and Exterior Use: As indicated on the Drawings, provide chisel-pointed stainless steel anchors. Stainless steel anchors shall be AISI Type 304 or Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. All nuts shall conform to ASTM F594 unless otherwise specified.

      3) Deformed reinforcing dowels shall be A615 Grade 60, with 45-degree chisel-points at embedded end.

5. Anti-seize/anti galling lubricant: For use on all bolt and nut threads as recommended by manufacturer for each application. Anti-seize/anti-galling lubricant shall be MRO Solutions LLC Solution 1000; Permatex Anti-Seize Lubricant, Finish Line Anti-seize Assembly Lube, USS Ultra Tef-Gel, Loctite Heavy Duty Anti-Seize, Loctite LB 771 by Henkel or pre-approved equal. Manufacturers to provide products specifically for use with SS when required.

F. Galvanizing

1. Where project specific requirements, Standard Details, or these specifications require galvanization, provide galvanization according to the following:

a. Galvanization shall be performed in accordance with ASTM A-153. All exposed surfaces, including anchors, bolts, nuts, washers, etc. shall be fully bituminously coated in accordance with AASHTO M-190. Anchor bolts (non- head) shall conform to ASTM A-36 with tension test to be made (as required) on the bolt body or on the bar stock used for making the anchor bolts. Unless otherwise specified all other fasteners shall conform to ASTM A-307 for carbon steel externally and internally threaded standard fasteners Grade A or B. For use within manholes, the entire strap shall be 304 grade Stainless Steel (not galvanized) and all anchors and/or bolts, washers, and nuts shall be 316 grade Stainless Steel (not galvanized).

b. Repair damage to galvanized coatings using ASTM A780/A780M zinc rich paint for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces to which repair paint has been applied.

c. Surfaces to be repaired shall be clean, dry and free of oil, grease, pre-existing paint, corrosion and rust. Surface to be repaired shall be blast-cleaned to SSPC-SP 10 (near white). Where circumstances do not allow blast or power tool cleaning to be used, then hand tools may be used. Cleaning shall meet SSPC-SP 2, the removal of loose rust, mil scale or paint to the degree specified, by hand chipping, scrapping, sanding and wire-brushing. Surface preparation shall extend into the undamaged galvanized coating.

d. Instead of repairing by painting with organic zinc repair paint, other methods of repairing galvanized surfaces that are abraded or damaged are allowed provided the proposed method is acceptable to the Engineer.

G. Steel Reinforcing For Concrete:

1. Bars: All reinforcement bars shall conform to the Standard Specifications for billet-steel bars for concrete reinforcement, ASTM A-615, or low alloy steel deformed and plain bars for concrete reinforcement, ASTM A-706. All bars shall be deformed and of structural Grade 60.

2. Wire: All reinforcement wire fabric shall conform to the Standard Specifications for welded steel wire fabric for concrete reinforcement, ASTM A-185 and steel wire, plain, for concrete reinforcement, ASTM A-82. Minimum yield strength shall be 65,000 PSI and minimum tensile strength shall be 75,000 psi.

H. Helical Piles: This work shall consist of constructing helical piles as shown on the Standard Details in accordance with these Specifications.

1. The helical piles/anchors shall have a central shaft that is cold formed welded and seamless carbon steel structural round tubing with a minimum yield strength of 65 ksi and meeting the dimensional and workmanship requirements of ASTM A500.

2. Helix Plates:

a. Shall conform to ASTM A-36 and have minimum yield strength (Fy) of 50 ksi.

b. Shall have a minimum thickness of 3 /8”.

3. All other flat plate steel shall conform to ASTM A-36 unless noted otherwise on the plans.

4. All coupling connection thru bolts shall be ¾" diameter and conform to SAE J429 Grade 8 or equivalent. (minimum yield strength (Fy) = 130 ksi and minimum tensile strength (Fu) = 150 ksi)

5. All piling sections and brackets shall be hot dipped galvanized, in compliance with ICC-ES acceptance criteria AC228 for corrosion resistance.

6. All helical pile components shall be selected to provide a minimum factor of safety against ultimate mechanical failure of two (2).

7. Helical piles shall be designed by a North Carolina licensed Professional Engineer in accordance with the current International Building Code (IBC) adopted by the local jurisdiction.

8. The helical pile shall be recognized by the International Code Council (ICC) and the manufacturer shall hold a current ICC-ES issued ESR report showing compliance with AC358 and the current International Building Code (IBC).

2.12 BEDDING MATERIALS - STONE AND BRICK/BLOCK

A. Granular Bedding Material: All bedding material shall be angular, clean washed crushed stone graded in accordance with Size #57, Size #67, or Size #78M in ASTM D-448 for "Standard Sizes of Coarse Aggregate" (NCDOT Standard size #57, #67 and #78). Bedding material will be used only as instructed in the Specifications and/or as specifically directed by the Engineer.

B. Stone Stabilization Material: All stone stabilization material shall be angular, clean washed crushed stone graded in accordance with standard sizes #467 in ASTM D- 448, (NCDOT Standard size #467M). Stabilization material will be used only as instructed in the specifications and/or as specifically directed by the Engineer. In conditions unsuitable for use of #467 stone, larger material conforming to NCDOT Class A, B, 1, and 2 stone and ASTM D-448 standard size #357 stone may be used as directed by the Engineer and shall meet the following class and size distribution.

Required Stone Sizes, Inches			
Class	Minimum	Midrange	Maximum
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

No more than 5% of the material furnished can be less than the minimum size specified nor no more than 10% of the material can exceed the maximum size specified.

Weight Percent Passing Each Sieve				
Size No.	Nominal Size Square Openings	2 ½ Inches	2 Inches	1 Inch
#357	2 inches to No. 4	100	95 to 100	35 to 70

C. Foundation Material: Foundation materials shall consist of field stone or rough unhewn quarry stone. The stone shall be sound, tough, dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended. All stone shall meet the approval of the Engineer. While no specific gradation is required, there should be equal distribution of the various sixes of the stone within the require size range. The size of an individual stone will be determined by measuring its long dimension. No more than 5% of the material can be less than the minimum size specified and no more than 10% can exceed the maximum size specified. Foundation material will be used only as instructed in the specifications and/or as specifically directed by the Engineer.

REQUIRED STONE SIZES - INCHES			
NCDOT CLASS	MINIMUM	MIDRANGE	MAXIMUM
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

D. Clay Brick: All brick used to construct manhole inverts or adjust frames shall be made from clay or shale, shall be solid only and shall be of standard building size. All brick shall meet or exceed the compressive strength and water absorption properties specified in ASTM C-32 for Grade MS brick or in ASTM C-216 and ASTM C-62 for Grade SW brick.

E. Concrete Brick/Block: All concrete brick/block used to make vertical manhole adjustments shall be solid, of standard building size and meet the requirements of ASTM C55 for Grade S-II. Concrete brick/block shall conform to NCDOT requirements and shall be red tinted per NCDOT requirements. Concrete brick/block may be used in vertical manhole height adjustments as shown on the Standard Details, or when approved by the Engineer, and shall NOT be used in invert work.

2.13 MICROPILES

A. Micropiles: This work shall consist of constructing micropiles as shown on the Standard Details in accordance with these Specifications.

1. Admixtures for Grout: Admixtures shall conform to the requirements of ASTM C494/AASHTO M194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of CHARLOTTE WATER. Admixtures shall be compatible with the grout and mixed in accordance with the manufacture's recommendations. Expansive admixtures shall only be added to the grout used for filling sealed

encapsulations and anchorage covers. Accelerators are not permitted. Admixtures containing chlorides are not permitted.

2. Cement: All cement shall be Portland cement conforming to ASTM C 150/AASHTO M85, Types II, III or V.

3. Centralizers and Spacers: Centralizers and spacers shall be fabricated from schedule 40 PVC pipe or tube, steel, or material non-detrimental to the reinforcing steel. Wood shall not be used. Centralizers and spacers shall be securely attached to the reinforcement; sized to position the reinforcement within ½ inch of plan location from center of pile; sized to allow grout tremie pipe insertion to the bottom of the drillhole; and sized to allow grout to freely flow up the drillhole and casing and between adjacent reinforcing bars.

4. Encapsulation: Encapsulation (double corrosion protection) shall be shop fabricated using high-density, corrugated polyethylene tubing conforming to the requirements of ASTM D3350/AASHTO M252 with a nominal wall thickness of 1/32inches. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of ¼ inch and be fully grouted with non-shrink grout conforming to this section.

5. Epoxy Coating: The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.01 inches. Epoxy coating shall be in accordance with ASTM A775 or ASTM A 934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated. TS-67.0 – 1.

6. Fine Aggregate: If sand – cement grout is used, sand shall conform to ASTM C 144/AASHTO M45.

7. Grout: Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 2000 psi and a 28-day compressive strength of 4000 psi per AASHTO T106/ASTM C109.

8. Grout Protection: Provide a minimum 1-inch grout cover over bare or epoxy coated bars (excluding bar couplers).

9. Permanent Casing Pipe: Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness as determined by the Engineer. The permanent steel casing/pipe shall meet the Tensile Requirements of ASTM A252, Grade 3, except the yield strength shall be a minimum of 50 ksi to 80 ksi.

10. Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to ASTM A 36/AASHTO M31, Grade 420 or Grade 520 or ASTM A722/AASHTO M275, Grade 1035.

2.14 ANTI-SEEP COLLARS

Anti-seep collar shall be placed at the downstream (utility line gradient) wetland boundary and every 150 feet up the gradient exits the wetland.

A. Concrete

1. Anti-seep collar shall be placed at the downstream (utility line gradient) wetland boundary and every 150 feet up the gradient exits the wetland. Concrete anti-seep collar may be constructed with class B concrete meeting the following specifications:

a. Minimum cement content, sacks per cubic yard with rounded coarse aggregate 5.0

b. Minimum cement content, sacks per cubic yard with angular coarse aggregate 5.5

c. Maximum water-cement ratio gallons per sack 6.8

d. Slump range 2" to 4"

e. Minimum strength - 28-day psi 3,600

B. Compacted Clay (Bentonite)

1. Compacted clay (bentonite) shall be tested by an independent soils lab to verify its suitability and shall have a specific infiltration of 1 x 10^{-5} cm/sec or less. The clay source material shall be laboratory tested/verified prior to approval by the Engineer. Testing shall be performed by a materials testing laboratory and certified by a geotechnical Professional Engineer or Professional Geologist. Placement of clay anti-seep collars shall be as shown on the construction plans and/or where directed by the Engineer. The clay anti-seep collars shall conform to the Standard Detail. Clay shall be compacted to a minimum of 98% of maximum dry density. Compaction test shall be required on each anti-seep collar.

2.15 ANTI-FLOTATION COLLARS

A. Contractor to provide submittals that include the following information:

1. Provide PE stamped anti-flotation calculations by an Engineer registered in the State of North Carolina.

2. Provide maximum spacing between consecutive anti-flotation collars.

3. Collars shall comply with the Standard Detail requirements.

2.16 ANTI-FLOATATION STONE FILLED SADDLEBAGS

A. Stone Filled Saddlebags: Where shown on the plans, engineered geotextile fabric with weights may be used in lieu of anti-flotation collars. Contractor to provide submittals that include the following information:

1. Provide PE stamped anti-floatation calculations by an Engineer registered in the State of North Carolina.

2. Provide UV treated geotextile fabric material that is non-biodegradable and resistant to acidic soils.

3. Grams per square meter (GSM), tensile and puncture strength for the engineered geotextile fabric material.

4. Provide filled weight and gradation of stone used to weigh down pipe.

5. Provide maximum spacing between consecutive saddlebags.

6. Bags may be filled with washed stone or sand, as recommended by the manufacturer.

7. Provide a submittal package for review and approval.

2.17 TRACER WIRE AND WARNING TAPE

A. Sewer Detectable Warning Tape:

1. Shall be 6-inch wide, with 5-mil thickness, green and black tape located 24 inches below finished grade.

2. Warning tape shall be brightly colored non-biodegradable plastic ribbon. The words “Warning Buried Sewer Line Below” shall be printed continuously along the length of the ribbon in large letters.

3. Approved Products:

   a. Brady Underground Utility Marking Tape

   b. Terra Tape

   c. Seton Detectable Underground Warning Tape

   d. Pre-Approved equal by CHARLOTTE WATER

B. All main line sewer pipe and lateral pipe shall be installed with copper tracer/locator wire, regardless of pipe material.

C. Tracer/Locator Wire System: The tracer wire shall be a single conductor AWG No. 12 (gauge) solid copper wire with HDPE insulation. The insulation shall be green and shall be 30 mils thick for open cut installation or 45 mils thick for Horizontal Directional Drill (HDD) installation. HDD installations shall require 2 conductors. The copper conductor wire shall conform to the requirements of ASTM B-3. Tracer wire shall be furnished in coiled rolls of 500-feet or greater length. Tracer wire will be secured to the pipe every 10 feet using an HDPE zip tie or Duct Tape. A 24-inch pigtail will be provided in each manhole, vault, valve box, cleanout, or any structure exposed to daylight.

1. The wire may be of domestic manufacture or import.

2. The product markings shall be at intervals of not more than 5 feet. The minimum product markings shall include the production record code, conductor average wire gauge (“AWG No. 12”), manufacturer’s name or trademark, and the insulation rating. All markings shall be clear and legible.

D. Wire Splice System: Tracer wire shall be as continuous as possible to the greatest extent. When wire splices are required, they shall conform to the Standard Details and shall be made with a butt splice, and three layers of vinyl and rubber tapes. The butt splice shall be made with copper alloy split connector or copper crimp connector.

1. The splice system may be of domestic manufacture or import and shall be preapproved by CHARLOTTE WATER.

2. The product packaging shall indicate approved conductor type and size, the manufacturer’s name, product name or number, and that the product is designed for direct bury and submersible installations. All markings shall be clear and legible.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION, GENERAL

A. Care of Coatings and Linings: Pre-cast manholes, pipe and fittings, frames, rings and covers, miscellaneous steel, steps, straps, etc., shall be so handled such 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 their expense in a manner satisfactory to the Engineer.

B. General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

C. In all instances pipe shall be laid in a workmanlike manner, true to line and grade, with bell ends facing up-grade in the direction of laying. The various pipes referred to herein shall be handled, belled up and laid in accordance with the manufacturer's requirements and good engineering practices as defined in the various publications referenced in this document. The following requirements and/or standards of the CHARLOTTE WATER shall govern this construction unless exceeded by other regulatory bodies.

D. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use dry bore with encasement, auger without encasement, dry punch/mole, pipe-jacking process, or microtunneling, as shown on the plans or as approved by the Engineer.

F. Pipe Bedding: Unless otherwise specified or noted on the Plans the following bedding classes are commonly required by CHARLOTTE WATER. When filter fabric is required to be placed over the granular bedding and pipe, as shown on the Standard Details, the fabric shall be Mirafi 140N or approved equal. When granular material embedment is required, the Contractor will backfill above the granular bedding as specified for Type I bedding to an elevation one (1) foot above the top of pipe bell.

1. Type I - Shaped Bottom Bedding: The trench bottom shall be shaped so the pipe bears uniformly upon undisturbed native earth. Soil shall then be placed by around the pipe and completely under the pipe haunches in uniform layers not exceeding six (6) inches in depth up to an elevation one (1) foot above the top of the pipe bell. Each layer shall be placed and then carefully and uniformly compacted, so that the pipe is not damaged nor the alignment disturbed.

2. Type IA – Granular Shaped Bottom Bedding: The trench bottom shall be shaped so the pipe bears uniformly upon undisturbed native earth. The pipe haunches shall be filled with an approved stone to a vertical height of one-fourth the outside diameter of the pipe bell for the pipe's entire length and for the entire width of the ditch. Type IA granular shaped bottom bedding may be used in lieu of Type I shaped bottom bedding. Soil shall then be placed by around the pipe and completely in uniform layers not exceeding six (6) inches in depth up to an elevation one (1) foot above the top of the pipe bell. Each layer shall be placed and then carefully and uniformly compacted, so that the pipe is not damaged nor the alignment disturbed.

3. Type II - Granular Material Embedment: The trench bottom shall be undercut a minimum of six (6) inches below the pipe barrel grade and filled with an approved stone to an elevation such that the pipe will be completely and uniformly bedded to a vertical height of one-third the outside diameter of the pipe bell for the pipe's entire length and for the entire width of the ditch. Depending upon soil and ground water conditions, greater depths (undercut) may be required to create a stable condition. Type II granular material embedment shall be used as directed by the Engineer. When ground water or bedrock is encountered, a minimum bedding of Type II is required.

4. Type III – Granular Material Embedment: The trench bottom shall be undercut a minimum of six (6) inches below the pipe barrel grade and filled with an approved stone to an elevation such that the pipe will be completely and uniformly bedded to vertical height of one-half the outside diameter of the pipe bell for the pipe's entire length and for the entire width of the ditch. Depending upon soil and ground water conditions, greater depths (undercut) may be required to create a stable condition. Type III granular material embedment shall be used when required for the pipe material and as directed by the Engineer.

5. Type IV – Granular Material Embedment: The trench bottom shall be undercut a minimum of six (6) inches below the pipe barrel grade and filled with an approved stone to an elevation such that the pipe will be completely and uniformly bedded to a vertical height equal to the outside diameter of the pipe bell for the pipe's entire length and for the entire width of the trench. Depending upon soil and ground water conditions, greater depths (undercut) may be required to create a stable condition. Type IV granular material embedment shall be used as directed by the Engineer.

6. Type V – Granular Material Embedment: The trench bottom shall be undercut a minimum of six (6) inches below the pipe barrel grade and filled with an approved stone to an elevation such that the pipe will be completely and uniformly bedded to a vertical height of twelve (12) inches above the outside diameter of the pipe bell for the pipe's entire length and for the entire width of the trench. Depending upon soil and ground water conditions, greater depths (undercut) may be required to create a stable condition. Type V granular material embedment shall be used as directed by the Engineer.

7. Type VI – Flowable Fill Embedment: 6 inches below pipe, up to the spring line with excavatable flowable fill, for use adjacent to lakes and ponds, when the pipe is more than 6 feet below full pond, or when excavation occurs within 45 degree line sloping out and down from toe of a foundation slab. Depending upon soil and ground water conditions, wider trenches may be required to create a stable condition in poor soils that cannot brace the flowable fill. Type VI flowable fill embedment shall be used as directed by the Engineer.

8. Stone Stabilization: When the bottom of the trench is not sufficiently stable to prevent vertical or lateral displacement of the pipe after installation with Type III bedding, stone stabilization will be required to develop a non- yielding foundation for the bedding and pipe. When such conditions are encountered, the trench will be excavated to a depth as great as 2 ½ feet below the pipe bell, or as determined by the Engineer, and #367 or #467 crushed stone, ballast stone or rip rap will be placed to an elevation six (6) inches below the bottom of the pipe. The pipe will then be

laid with Type III through Type VI (6) bedding as directed by the Engineer. Stabilization techniques utilizing a geotextile fabric may also be permitted or required by the Engineer.

9. Stone Foundation: When the bottom of the trench is not sufficiently stable to prevent vertical or lateral displacement of the pipe after installation of feet of stabilization stone material, stone foundation materials will be required to develop a non-yielding foundation for the stone stabilization, bedding and pipe. When such conditions are encountered, the trench will be excavated to a depth, as determined by the Engineer. Class A, B, 1, or 2 stone foundation materials will be placed to an elevation determined by the Engineer. Layering of several classes of stone foundation materials may be required by the Engineer. Stabilization stone shall be used between the stone foundation materials and the bedding stone as determined by the Engineer. The pipe will then be laid with Type III, through Type VI (6) bedding as directed by the Engineer. Should the Engineer determine that the stone foundation material is not capable of providing a non-yielding foundation, then concrete cradles or piers shall be required as specified below. Excavation and disposal of undercut materials necessary for installation of stone foundation material is included as part of stone foundation.

10. Concrete Encasement and Cradles: Shall be as designed for each individual case and will be noted on the Plans and in the Special Provisions when applicable.

3.2 PIPING INSTALLATION, GRAVITY-FLOW, NON-PRESSURE PIPE

A. Installation Depth Limitations: The following are limitations and bedding requirements for supportive strength and shall be adhered to at all times. Granular material embedment may still be required for lesser depths of cover should groundwater, bedrock, and/or soil conditions warrant its use, as determined by the Engineer.

B. Trench width:

1. The minimum trench width shall be defined as the minimum trench width necessary to accommodate compaction equipment necessary to achieve required compaction. Trench widths must be maintained constant as measured at the top of the pipe.

2. Maximum trench width general requirements:

a. Pipe Size Diameter 4-inch to 16-inch: Maximum Trench Width equals nominal pipe size diameter plus 30 inches.

b. Pipe Size Diameter 18-inch to 30-inch: Maximum Trench Width equals nominal pipe size diameter plus 36 inches.

c. Pipe Size Diameter larger than 30-inch: Maximum Trench Width equals nominal pipe size diameter plus 42 inches.

d. Deviations to listed trench widths must be approved by the Engineer. Deviation from the maximum trench width will necessitate an increase in the stone bedding around the pipe and/or a change in the type or class of pipe being installed at the Contractor's expense.

C. Ductile Iron Pipe: Installation of Ductile Iron Pipe shall be installed subject to the bedding limitations specified below, based on a deflection limit of three (3) percent for cement

lining. Greater depths of cover may be achieved by using a higher pressure classification and/or using pipe with a flexible lining.

MAXIMUM DEPTH OF COVER - DIP				
Pipe Size	Pressure Class	BEDDING		
		Type I	Type II	Type III
8"	350	20’	34'	50'
10"	350	15’	28'	45'
12"	350	15’	28'	44'
14"	250	15’	23'	36'
16"	250	15’	24'	34'
18"	250	14’	22'	31'
20"	250	14’	22'	30'
24"	250	15’	20'	29'
30"	250	15’	19'	27'
36"	250	14’	18'	25'
42"	250	14’	17'	25'
48"	250	13’	17'	24'
54”	250		16’	24’
60”	250		16’	24’
64”	250		16’	24’

Table Note: Type II Bedding is minimum requirement allowed. Type I Bedding is allowed for installation of DIP 4-inch and 6-inch diameter laterals.

D. Poly Vinyl Chloride (PVC) Pipe: PVC pipe shall be installed with a minimum of 3.0 feet of cover and a maximum of 20 feet of cover. When the cover is less than 3.0 feet or more than 20 feet, Ductile Iron Pipe must be used subject to the specified limits. PVC pipe shall be installed in accordance with ASTM D-2321 (and/or ASTM D-2774) with the following limitations:

1. All PVC pipe shall be installed using Type III Granular Embedment or greater. Type I and Type IA Bedding is allowed for installation of PVC 4-inch and 6-inch diameter laterals. Minimum and maximum trench widths shall be as follows:

Pipe Size (inches)	Minimum Trench Width (inches)	Maximum Trench Width (inches)
4”	20	40
6”	22	42
8”	24	44
12"	28	48
16"	32	52
18"	34	54
20”	36	56
24"	42	60
30"	50	66
36"	57	78
42"	65	84
48"	72	90
54”	80	96
60”	87	102

a. Deviations to listed trench widths must be approved by the Engineer.

b. The bedding shall extend from the pipe to the trench wall or to two and one half pipe diameters (OD) on each side of the pipe, whichever is less.

E. Fiberglass Reinforced Polymer Mortar Pipe (FRPMP): FRPMP shall be installed according to AWWA M45 and ASTM D3262 with the following limitations:

1. Trench Width

a. The minimum trench width shall provide sufficient working room at the sides of the pipe to permit accurate placement and adequate compaction of the pipe zone backfill material. Minimum trench widths are given in the table below:

Nominal Diameter (in.)	Minimum Trench Width (in.)
18 to 20	Diameter + 12
24 to 33	Diameter + 18
36 to 48	Diameter + 24
51 to 72	Diameter + 36
78 to 126	Diameter + 48

b. There is no maximum limit on trench width, however, it is required that the pipe zone backfill materials be placed and compacted as specified for the

full width of the trench or a distance of 2.5 diameters on each side of the pipe, whichever is less.

2. Supported Trench

a. When a permanent or temporary trench shoring is used, minimum trench width shall be as per above. When using movable trench supports, care should be exercised not to disturb the pipe location, jointing or its embedment. Removal of any trench protection below the top of the pipe and within 2.5 pipe diameters is not recommended after the pipe embedment has been compacted unless all voids created by sheeting removal are filled with properly densified embedment material and any loose soils at pipe zone elevation are properly compacted prior to loading the pipe with overburden. When possible, use movable trench supports on a shelf above the pipe with the pipe installed in a narrow, vertical wall sub ditch.

3. Preparation of Trench Bottom

a. The trench bottom should be constructed to provide a firm, stable and uniform support for the full length of the pipe. Bell holes should be provided at each joint to permit proper joint assembly and alignment. Any part of the trench bottom excavated below grade should be backfilled to grade and should be compacted as required to provide firm pipe support. When an unstable subgrade condition is encountered which will provide inadequate pipe support, additional trench depth should be excavated and refilled with suitable foundation material. In severe conditions special foundations may be required such as wood pile or sheeting capped by a concrete mat, wood sheeting with keyed-in plank foundation, or foundation material processed with cement or chemical stabilizers. A cushion of acceptable bedding material should always be provided between any special foundation and the pipe. Large rocks and debris should be removed to provide six inches of soil cushion below the pipe and accessories.

4. Standard Embedment Conditions

a. FRPM shall be installed in accordance with Type V Granular Material Embedment as stated above in “Pipe Bedding”.

5. Type V Pipe Zone (Embedment) Backfill Materials

Bedding and pipe zone (embedment) backfill materials shall be as specified in this Chapter under Section 2 for “Granular Bedding Material”. Certain projects may warrant additional geotechnical information which may determine alternate bedding conditions, such projects should be addressed with specific consultation between the Engineer and CHARLOTTE WATER during project design.

a. Maximum grain size should typically not exceed 1 to 11/2 times the pipe wall thickness or 11/2 inches whichever is smaller.

b. Well graded materials that will minimize voids in the embedment materials should be used in cases where migration of fines in the trench wall material into the embedment can be anticipated. Alternatively, separate the open graded material from the non-cohesive soil with a filter fabric to prevent migration of the smaller grained soil into the open graded material. Such migration is undesirable since it would reduce the soil density near the pipe zone and thereby lessen the pipe support.

c. Embedment materials should contain no debris, foreign or frozen materials.

6. Bedding

a. A firm, uniform bed should be prepared to fully support the pipe along its entire length. Bedding material should be as specified by the standard embedment condition.

b. Initially place and compact bedding to achieve 2/3 of the total bed thickness. Loosely place the remaining bedding material to achieve a uniform soft cushion in which to seat the pipe invert (bottom).

c. After joining pipes, assure that all bell holes are filled with the appropriate embedment materials and compacted as specified.

d. Note: Do not use blocking to adjust pipe grade.

7. Haunching

a. A very important factor affecting pipe performance and deflection is the haunching material and its density. Material should be placed and consolidated under the pipe while avoiding both vertical and lateral displacement of the pipe from proper grade and alignment.

8. Backfilling

a. Pipe zone (embedment) material shall be as specified by the standard embedment condition.

b. Place and compact the embedment material in lifts to achieve the depths and densities specified by the standard embedment condition. Little or no tamping of the initial backfill directly over the top of the pipe should be done to avoid disturbing the embedded pipe.

c. Remaining backfill may be the native trench material provided clumps and boulders larger than three to four inches in size are not used until 12 inches of pipe cover has been achieved.

9. Pipe Deflection

a. Pipe initial vertical cross-section deflection measured within the first 24 hours after completion of all backfilling and removal of dewatering systems, if used, shall not exceed 2.75% of the original pipe diameter.

b. Pipe deflection after 30 days should not exceed parameters displayed in table under Section 3.12.G for FRPMP deflection standards. Maximum long-term pipe deflection is 5% of the original pipe diameter. Maximum long-term deflection for pipes with vinyl ester resin liner is 4%.

c. For very high stiffness pipes (approx. SN 120 and above), the maximum long-term deflection may be reduced and the 24 hour and 30-day deflection limits also decreased proportionally with Engineer's approval.

F. Grade and Line for Pipe: As a minimum, centerline hubs will be set at each manhole and offset stakes set at each manhole, and if required at 100-foot intervals between manholes. Cut sheets will show the vertical distance from the offset stakes to the inlet and outlet pipe invert at each manhole and to the pipe invert at each offset stake. For 30-inch diameter and larger pipe, each joint shall be checked with a grade rod and automatic self-leveling laser level.

Laser alignment beams shall be used to set line and grade. The Contractor shall provide adequate and accurate equipment for the Engineer to check their line and grade at each cut stake (lock levels shall not be considered adequate). The grade shall be checked at each manhole and at benchmarks every 500 feet.

For pipe larger than 30-inch in diameter, laser alignment beams shall generally be used to set line and grade. Each joint shall also be checked with an automatic self-leveling level and grade rod, and recorded as survey notes in a survey field book. The field book shall be reviewed by the Engineer periodically during construction and shall be provided to the Engineer at the end of construction.

The Contractor shall keep close check of their laser for variations in line and grade. No variations between manholes shall be corrected without relaying that portion of line which has deviated from line or grade unless otherwise approved by the Engineer.

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place watertight plug in end of incomplete piping at end of day and when work stops during the day/shift.

Construction Staking (Excluding Developer Donated Projects): Contractor is responsible for staking gravity sewer manholes, easements, rights-of-ways, limits of disturbance, tree protection fence line, wetland boundaries, buffers, Project Control Points and other horizontal control reference points and benchmarks for the work shown on the Drawings. CHARLOTTE WATER will provide a drawing and/or staking plan files in electronic format to Contractor. Contractor shall confirm all drawing dimensions and elevations and establish elevations, lines, and levels from reference points, utilizing recognized engineering survey practices. During construction, Contractor shall provide competent helpers for checking elevations, lines, and levels deemed necessary by CHARLOTTE WATER. Contractor shall establish horizontal and vertical control benchmarks and reference points on the site located in prominent and protected places as agreed upon by Contractor and CHARLOTTE WATER. Construction Staking must be approved by a Professional Land Surveyor registered in the State of North Carolina.

1. Prior to construction, the Engineer will provide the following construction layout for each pipeline project:
    a. Centerline of each proposed manhole, structure, pier and/or centerline of proposed end of main will be established and offset referenced.
    b. Begin and end point of proposed mainline dry bore with steel encasement or tunnel will be established and offset referenced centerline.
2. Permanent or temporary benchmarks will be established by Contractor at or near:
    a. Connection to existing main
    b. Each proposed manhole
    c. Proposed end of main
    d. Proposed piers
    e. Mainline bore with encasement or tunnel
3. The Contractor is responsible for protecting these control points until construction is complete. All other construction layout and surveying, which may be required for construction, shall be provided by the Contractor. The Contractor is responsible

for determining the amount of additional construction layout and surveying that may be required to complete construction.

3.3 LATERAL INSTALLATION

A. 4-inch laterals may connect to new mains at manholes, with cored holes with compression rubber boots, or at tees in new mains. 4-inch laterals may connect to existing mains at manholes with cored holes with compression rubber boots or at cored taps with tapping saddles in existing mains.

B. 6-inch lateral connections may connect to new mains at manholes with cored holes and compression rubber boots or at tees in the new main. 6-inch lateral connections to existing mains may connect at manholes with cored holes with compression rubber boots or at tees installed in existing 8-inch and 10-inch mains. 6-inch laterals may connect to existing 12 inch and larger mains with a cored tap with tapping saddles into the existing main, or may connect at manholes with cored holes and compression rubber boots.

C. 4-Inch and 6-Inch Laterals: 4-inch and 6-inch diameter laterals shall be connected to the main with tees as previously specified if the lateral is installed during the construction of the main. 4-inch and 6-inch diameter laterals shall be connected to existing mains with saddles placed in holes cored by an approved coring machine, or hole saw, as applicable. Saddles and tees shall be as previously specified and as shown on the Standard Details. When approved by the Engineer, tees may be cut into the existing main in lieu of tapping.

D. 4-inch and 6-inch sewer laterals shall extend from the main to the property line or right-of-way line using a 22–½ or 45-degree vertical bend at the tee or saddle and pipe as previously specified and as shown in the Standard Details. The lateral shall be laid with a minimum slope of 1.5% (3/16” per foot) for 4-inch laterals and 1.25% (1/8” per foot) for 6-inch laterals. All tees, saddles and bends shall be completely encased in #57 washed stone. An "S" shall be cut in the curb at the location where lateral crosses under curb.

E. A schedule 40 PVC pipe clean out shall be installed on 4-inch and 6-inch diameter laterals, immediately outside the right-of-way, on the applicant’s property as detailed in the Standard Details. The clean out shall consist of a DR 18 PVC wye and 1/8 bend, vertical Schedule 40 PVC standpipe, and schedule 40 PVC tailpiece. Vertical standpipe shall end with a removable airtight plug. Tailpiece shall end with a solvent weld PVC plug.

F. If the cleanout is installed in paved areas, driveways, or concrete, the top section must be cast iron with a cast iron lid.

G. Pools will require maximum 4-inch diameter sewer laterals.

H. Laterals shall not be installed within the curb radius point, unless the lot only fronts the road right-of-way inside the radius points, or otherwise approved by CHARLOTTE WATER.

I. Cleanouts for 4-inch diameter laterals in maintained yards shall be flush with finish grade, with a sewer valve box assembly. Cleanouts in un-maintained yards or yards still under construction shall extend vertically to one-foot above finish grade, or flush with a valve box assembly, as directed by the Engineer. The lateral shall terminate with a 3-foot long tailpiece, immediately behind the clean out. A treated lumber post (4" x 4") shall be placed behind the plug and extend vertically to one-foot above finish grade, if required by the Engineer.

J. Single Family home private pressurized sewer lines may discharge into cleanouts. Commercial private pressurized sewer lines shall discharge into private manholes, located outside of the road right-of-way or outside the CHARLOTTE WATER sewer easement, regardless of the size of the lateral.

K. In subdivisions constructed without curb, the Contractor will paint an “S” on the edge of pavement at the location where the lateral crosses under the edge of pavement. Markings will be made using green paint.

L. All laterals except those serving lots adjacent to in-line manholes or upstream from dead-end manholes in cul-de-sacs shall be connected to the sewer main. Laterals connected to the main shall be installed 90 degrees to the main. Angled laterals are prohibited unless connected to a manhole. Laterals connected to manholes shall be laid on a line from the center of the lot to the center of the manhole and shall extend not more than six inches inside the manhole wall. Terminal manholes located in cul-de-sacs shall have a maximum of three (3) laterals. Any in line manhole shall have a maximum of two (2) laterals, with each lateral entering the manhole from an opposing side to the other lateral. The lateral elevation entering the manhole shall match crown to crown with the main entering the manhole and a trough shall be formed for the lateral invert. Laterals that are connected to outfall lines shall enter the manhole at the shelf, matching crown to crown with the outfall pipe, and an invert shall be cut into and/or formed in a sweeping motion to carry the lateral flow to the downstream invert.

M. The laterals shall be installed with a minimum of four (4) feet of cover at the easement line/road rights-of-way and curb line, unless otherwise approved by CHARLOTTE WATER. The depth of the lateral at the easement line shall not be greater than what is required to serve the lot/building. The Contractor will not backfill any portion of the lateral connection to the main, cleanout or bends, until the installation is approved by a CHARLOTTE WATER Inspector.

N. Spacing Requirements shall be as follows:

1. Minimum spacing between tees/taps along the sewer line shall be 7.0 feet, and a minimum of 3.0 feet from pipe joints.
2. Minimum spacing from outside face of manhole and tees/tap shall be 7.0 feet.
3. Minimum spacing from water service shall be 5’ or distance equal to depth of sewer lateral, whichever is greater.
4. Minimum spacing from parallel storm pipe shall be 5’ or distance equal to depth of sewer lateral, whichever is greater.
5. Minimum spacing from catch basins shall be 5’ or distance equal to depth of sewer lateral, whichever is greater.
6. Minimum spacing from property lines shall be 3’ or distance equal to depth of sewer lateral, whichever is greater.

O. Measurements: The Inspector, assisted by the Contractor, will measure the distance to the tee or tap from the down-stream manhole to obtain the information required for the "As-Built" records.

P. 8-Inch and Larger Laterals: 8-inch and larger diameter laterals shall connect to manholes with the lateral crown level with the crown of the main line pipe, or with inside or outside drops, in accordance with Specifications and Standard Details for mainline construction. When the lateral is the same diameter as the main line pipe, a drop of 0.2 feet will be

provided in the manhole between the invert of the lateral and the invert of the main line pipe. The lateral shall be laid with a minimum slope of 0.60%, and no more than a maximum of 10%, or as approved by the Engineer.

Q. 8-inch and larger laterals shall extend from the main to the easement line or road right-of-way line. The lateral shall terminate immediately outside the right-of-way, and shall be plugged with a removable airtight cap or plug. A treated lumber post (4" x 4") shall be placed behind the plug and extend vertically to one-foot above finish grade.

R. 8-inch and larger laterals serving more than one structure are considered public mains and shall be permitted/tested accordingly.

S. Cleanouts are not permitted on 8-inch or larger pipes.

T. For developer installed services, the lateral shall terminate immediately outside the right of way or easement, in a private manhole.

U. Due to air testing requirements, a temporary solvent weld plug may be required on the cleanout. Due to the gasketed wye and bend, the vertical standpipe may require counterweights (such as sandbags) during required air testing. Temporary solvent weld plugs, if used, shall be removed after testing, and the permanent screw in plug assembly installed.

V. All laterals, standpipe and fittings in the air test section shall be properly capped or plugged, and carefully braced against the internal pressure to prevent air leakage by slippage and blowouts.

W. Sewer tapping saddles on DIP within a 100-foot radius of a well shall be as specified for water main tapping sleeves. A tapping valve is not required. In lieu of the tapping saddle, a ductile iron tee may be installed or cut-in. All pipe including lateral pipe and cleanouts within the 100-foot radius of the well shall be ductile iron as specified.

3.4 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated. Manhole vents, frames and covers shall be installed immediately following installation of manholes for safety and flooding reasons. Manholes shall be clean and free of any and all debris.

B. All manholes outside street rights-of-way or landscaped areas shall be constructed to a height of two (2) feet above the adjacent ground unless otherwise indicated on the Plans or by the Special Provisions. Manholes within street rights-of-way or landscaped areas shall have finished rim elevations flush with the pavement or adjacent finished grade. After final inspection is complete and all deficiencies have been corrected, the Contractor shall lock all cam-lock style frames and covers in the closed or locked position.

1. Precast Reinforced Concrete Structures: All precast manhole sections shall conform to these Specifications and Standard Details. Precast manholes shall be treated similar to pipe for installation. That is, if ground water and/or soil conditions require stabilization for pipe installation comparable measures will be required for precast manhole installation. Under no circumstances will a precast base section be placed on unstable soil as solely determined by a Geotech Engineer and/or the Engineer. Jointing of precast sections will be done in accordance with the manufacture's recommendation, with special attention called to the amount of force used. Joints shall be made watertight by two (2) rings of butyl rubber joint sealant placed in the joint prior to joint assembly. Sealant shall be sized as recommended

by the manhole manufacturer. After the joint is assembled, an exterior joint wrap shall be applied to the exterior of the completed joint, as indicated in the Standard Detail. After completion of manhole construction, the manhole shall be subjected to a vacuum as specified for manhole vacuum testing, for approximately 10 minutes to seat the manhole joints and compress the butyl rubber joint sealant. The time required to seat the joint may be temperature dependent, and shall be complete when the joint sealant has fully filled the joint annular space, as determined by visual inspection. All backfill around structures shall be thoroughly tamped in layers as specified for placing backfill. Regardless of the type of manhole construction used, the Contractor will do that which is necessary to stabilize the soil intended to support the structure. A stable condition shall only be so adjudged by the Engineer or their authorized representative. Any cost incurred by the Contractor in stabilizing the area to support a manhole shall be considered incidental to the manhole construction.

2. Outside Drops: When design considerations dictate a large elevation change across a manhole, outside drop manholes may be used at the discretion of the Engineer on a case-by-case basis, constructed in accordance with the Standard Details. Depending on the particular fittings used, elevation differences of 2.0 to 2.5 feet are required to accommodate an outside drop. When there is not sufficient elevation difference to permit construction of an outside drop, the grade of the influent pipe shall be lowered such that the vertical separation of the influent and effluent pipes is 0.2 feet, as measured at the center of the manhole when the grades of both pipes are projected to that point. Outside drops shall not enter the cone section of precast manholes, or be within 4 inches of a manhole joint assembly, as measured from the edge of the core.

3. Inside Drops: When connecting a proposed sewer main to an existing 5-foot diameter or larger manhole at an elevation significantly higher than the existing invert elevation, the connection may be made with an inside drop constructed in conformance with the Standard Details. Inside drops will be used only where shown on the plans or specifically approved by the Engineer. Inside drops shall not enter the manhole in the cone section, or be within 4 inches of a manhole joint assembly. Inside drops are not allowed on four (4) feet diameter manholes. Inside drops shall have downspout piping one pipe diameter larger than an inlet pipe diameter, as shown on the Standard Details. Un-piped drops are prohibited.

4. Installation Of Frames and Covers: The frame shall be installed on the manhole with anchor bolts on all manholes. 7.5-inch tall frames shall be used for manholes located in the road right-of-way and manholes located outside of the road right-of-way. These frames shall have holes in the support flange to permit installation on the cone with anchor bolts. Holes shall be equally spaced in the flange. Complete anchor bolt assemblies shall be zinc plated steel and shall consist of an epoxy adhesive anchor, a threaded stud, a double size washer, a standard washer, and two nuts. Use of “red head” mechanical anchoring assemblies are prohibited. Anchors shall be installed in field drilled holes in the cone, and/or adjustment grade rings. Minimum diameter of the threaded stud shall be 1/2 inch. The Contractor shall seal the frame to the manhole by installing 2 rings of butyl rubber joint sealant to form a gasket between frame and manhole. The butyl rubber joint sealant shall have a one inch cross section, and shall make two full circles when placed on the cone section, and shall be compressed by the frame with the anchor bolts. Cement mortar grouting of the frame shall be required as shown on the Standard Details. Brick may not be used to adjust rim elevations of above

grade manholes. Manholes that are installed flush with pavement or grade shall have frames attached to the manhole with anchor bolts. Precast concrete, recycled rubber or expanded polypropylene (EPP) adjustment grade rings may be used to adjust the finished rim elevation of such manholes. Anchor bolts shall extend through grade rings into the cone section, per the Standard Details. Recycled rubber and Expanded polypropylene (EPP) grade rings shall be installed according to the manufacturer's recommendations. This adjustment using expanded polypropylene or recycled rubber grade rings may not exceed 8 inches in height (total). The maximum adjustment height from top of precast concrete cone section to top of frame shall not exceed 21-inches in height.

5. Manhole Step Testing: The Contractor will furnish a hydraulic driven system consisting of cylinder, connecting hose and above ground pump with gauge to test manhole steps to exceed 1000 lbs. of resistance of pullout. All field installed steps will be tested. In lieu of field testing steps installed at the plant, certified shop test reports by the manufacturer showing that each step passed the required 1000 lb. pullout will be accepted. The test report certificates will be furnished to the Inspector prior to field installation of the manhole. Unless the Contractor can furnish the manufacturer's certification on step tests, the Contractor will be required to test 10% of the plant installed steps. An additional 10% will be tested for each failure. Failed steps shall be re-installed and re-tested until passing results are approved by the Engineer.

6. Steel Vent Pipes: Steel vent pipes will be installed in accordance with the Standard Details. Shop drawings of strap on vents, mounting straps, and anchor bolts will be subject to approval of the Engineer. Material shall be as specified Part 2, Products. Vent pipes shall be grouted watertight into the precast concrete manhole cone section or may be connected using a rubber manhole/pipe boot connector.

7. Polymer Concrete Manholes

   a. Verify that lines and grades are correct.

   b. Structures shall be constructed to the dimensions shown on the Drawings and as specified herein. Protect all work against flooding and floatation.

   c. Place the structure section plumb and level, trim to correct elevations.

   d. Place the structure base on a bed of minimum 6-inch thick depth of #57 stone base, suitable bearing capacity as approved by Geotechnical Engineer. Set manhole and base grade so that a maximum grade adjustment of 12-in is required to bring the manhole frame and cover to final grade.

   e. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with the manufacturer's instructions. Test all connections for water tightness before backfilling.

   f. Construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to the following criteria:

      1) Slope of invert bench: 1" per foot minimum, 1 ½" per foot maximum.

      2) Depth of bench to invert shall be at least equal to the largest pipe diameter.

3) Inverts slope through manhole: 0.20-foot drop across manhole with smooth transition of invert through manhole, or as shown on the approved construction plans.

g. Polymer bench and channel are to be constructed with all resin aggregate material. No alternative fill material is allowed.

h. Ladders for Polymer Concrete Manholes

1) Access to polymer concrete manholes should be via a field installed polypropylene vault ladder.

2) Ladder shall be fastened to the floor and wall with ½" x 3-3/4" Type 316 stainless steel anchors. Fastener brackets shall be installed on the wall at 4 feet intervals from the top of manhole.

a) Drill pilot hole using a hammer drill with a 3/8" diamond-tipped stop drill bit with 1-11/16" embedment shoulder to avoid drilling through wall.

b) Clear the resulting hole free of dust using compressed air or a vacuum/blower.

c) Fill cleared hole with anchoring adhesive.

d) Install anchor bolt in hole immediately after apply applying the anchoring adhesive.

e) Allow time for curing per manufacturer's recommendation.

f) Set ladder and tighten bolts.

C. Form continuous polymer concrete channels and benches between inlets and outlet.

3.5 PARSHALL FLUMES

A. Install products in accordance with Engineer's instructions, plans, blueprints, etc, local codes, and in a manner consistent with the installation instruction and recommendation of the manufacturer.

B. Ensure that the product is installed plumb and true, free of twist or warp, within the tolerances specified by the manufacturer and as indicated in the contract documents.

C. Nylon or fabric slings should be used in conjunction with a spreader bar to lift or move the manhole.

D. Excavate an area large enough to contain the manhole and the concrete pad while allowing for sufficient space to allow for a safe work environment.

E. Follow all OSHA requirements for open trench construction.

F. Pour a pad of sufficient width and length to support all of the manhole, the flume, and the connecting piping. The thickness of the pad shall be a minimum of 6i inches thick and shall be sized to ensure that proper loading is observed and that the manhole will not float. The surface of the pad should be level to within 1/8 inch.

G. Clean the concrete slab of all sharp objects and debris before laying the foam pad provided with the manhole.

H. If PVC boots are provided, install them on the manhole pipe stubs before lowering the manhole into the opening.

I. Lower the manhole onto the pad.

J. Drill holes in the base mounting flange, foam, and concrete pad to accept the stainless steel anchor bolts (supplied by others unless indicated in 2.2.E).

K. Check to ensure that the flume is level from side to side and from front to back, adjust the pad and anchor bolts, shimming if necessary.

L. Connect and secure piping.

M. Grout the areas between the flume and the concrete pad outside of the manhole.

N. Backfill with specified bedding material, 1/4 to 3/4 inch in diameter, using uniform lifts of no more than 12 inches.

3.6 PIERS

A. Pier locations as shown on the Plans shall be considered a guide only, with final determination made at the time of construction by the Engineer. Pier spacing center to center, will be as shown on the Plans, but all pier locations may be adjusted by the Engineer due to field conditions.

Piers will be placed parallel to the flow of the creek unless otherwise directed by the Engineer.

1. Steel Pile Piers: The work covered by this section consists of furnishing and driving piles, as indicated on the plans, the Standard Details, and as approved by the Engineer, in conformity with the specifications and to the bearing and penetration required.

   a. Installation: General - The pilings shall be driven to obtain a bearing capacity of 20 tons based on the following formula (the Engineering News Record Pile Driving Equation) and to a minimum depth of 10 feet in undisturbed earth below the bottom of the creek channel or existing ground when not adjacent to the creek.

      ENR Formula: $S = (2E/R) – C$

      S = penetration per blow (inches)

      R = specified bearing capacity (pounds)

      E = energy per blow (ft-lbs)

      C = 1.0 for drop hammer; 0.1 for air, or diesel hammer

      See Standard Details for approved H-pile types and sizes.

   b. Piles Lengths: Full length piles shall be used where practicable and not more than 2 pieces (1 splice) of steel pile will be permitted in making up one full length pile unless approved by the Engineer. Splices, where necessary and approved by the Engineer, shall be made as to maintain the true alignment and position of the pile sections. Both pieces of a spliced pile shall be the same shape.

      Splices should develop not less than 100 percent of the bending strength of the pile and not less than 100 percent of the axial load strength of the pile. All welded splices will be of full butt weld type. Back-up plates welded to the flanges and web of the steel piles are not required. All welding of

structural steel in the shop or in the field shall meet the requirements of the AWS Code and be done by qualified welders. Certification of welders and welds will be required by the Engineer in accordance with the AWS Code.

c. Driving: Steel piles shall be driven with a diesel, drop, or air hammer with a rated energy of not less than 15,000 ft. lbs., fixed leads and a ram weight of one (1) to one and a half (1.5) times the pile weight. In case the required penetration is not obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall provide a heavier hammer, at their own expense. The piles shall be driven on a batter of 15 degrees to the vertical or as shown on the plans, and shall not be out of position at the top of the pile by more than three inches in any direction after driving.

d. Cross Bracing: Cross bracing will be required only when the undisturbed ground level is below the intersection of the cross bracing.

e. Testing And Inspection: CHARLOTTE WATER will provide inspection and will determine bearing capacity of the driven piles. Piles may only be driven while under observation of the CHARLOTTE WATER Inspector. The Contractor shall schedule all pipe driving with the inspector. The Contractor will submit certification of rated hammer energy acceptable to the Engineer. A calibrated, certified scale must be made available upon request by the Inspector.

The Inspector will be present during all pile driving operations and the Contractor will provide them evidence that the average penetration for the last 10 blows is less than the S calculated by use of the above formula.

Test piles furnished and driven by the Contractor for their use in determining the lengths of piles to be furnished may be so located that they may be cut off and become a part of the completed structure, provided that such test piles conform to the specifications and are approved by the Engineer.

Test piles shall be driven with equipment of the same type and capacity as that used for driving piles for the structure.

Test piles which are not to be incorporated in the completed structure shall be removed to at least 2 feet below the surface of the ground or the stream bed, and the remaining hole backfilled with earth or other suitable material.

The Contractor shall give written notice a minimum of 72 hours before beginning construction on the steel piles in order to coordinate this work with CHARLOTTE WATER inspection staff.

Bolt holes shall be drilled with high speed drill bits. Acetylene torch bolt holes are prohibited. End cuts shall be ground straight and true, with burrs removed.

f. Repair damage to galvanized coatings using ASTM A780/A780M zinc rich paint for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces to which repair paint has been applied.

g. Surfaces to be repaired shall be clean, dry and free of oil, grease, pre-existing paint, corrosion and rust. Surface to be repaired shall be blast-cleaned to SSPC-SP 10 (near white). Where circumstances do not allow blast or power tool cleaning to be used, then hand tools may be used. Cleaning shall meet SSPC-SP 2, the removal of loose rust, mil scale or paint to the degree specified, by hand chipping, scrapping, sanding and wire-brushing. Surface preparation shall extend into the undamaged galvanized coating.

h. Instead of repairing by painting with organic zinc repair paint, other methods of repairing galvanized surfaces that are abraded or damaged are allowed provided the proposed method is acceptable to the Engineer of Record.

2. Concrete Piers: If the required penetration for a pile is not obtained, as determined solely by the Engineer, the Contractor may be directed to construct a reinforced concrete pier. The Contractor will not attempt to drive a second pile at a pier location at which the first pile did not achieve the required penetration unless the Engineer has determined that the first pile will be used.

A pile which will not be incorporated in the completed structure will be removed or cut off so that the top of the pile is below the concrete footing.

3. Helical Piers: Consisting of helical steel piers with one (or more) helically shaped steel plate attached to a central steel shaft. Piers are extended by adding shaft extensions.

a. Installers specializing in performing the work of this section with documented certification from the manufacturer.

b. Provide electric or hydraulic powered, rotary type installation torque units with forward and reverse capability which are capable of positioning the pier at the designed angle.

c. The minimum installation equipment rating shall equal or exceed the maximum torque rating of the specified helical pier.

d. Securely connect the installation equipment to the pier during installation.

e. Monitor torque applied by the installing units during the entire installation and record values achieved on each pier.

f. Provide a torque monitoring device as part of the installing unit or as a separate in-line device.

g. Make calibration torque monitoring data available for the Engineer of Record, Inspector, and CHARLOTTE WATER.

h. Position helical pier as indicated in drawings. Establish proper angular alignment at the start of installation.

i. Provide extension material to obtain indicated depth. Couple the helical pier and extension sections with bolts in accordance with International Conference of Building Officials (ICBO) report ER-5110.

j. Remove encountered obstructions, or relocate the helical pier and adjacent helical piers as required. Notify Engineer of Record of pier relocation requirement prior to helical pier placement.

k. Installation:

1) Connect the lead section to the torque motor using the drive tool and drive pins. Position and align the lead section at the location and to the inclination shown on the drawings and crowd the pilot point into the soil. Advance the lead section and continue to add extension sections to achieve the termination criteria. Connect extensions using bolts shown on drawings. Bolts shall be "snug-tight" per the ASIC. "the snug-tightened condition is the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the connected plies into firm contact". Bolts do not require a specific torque, do not over torque bolts. All sections shall be advanced into the soil in a smooth, continuous manner at a rate of rotation between 10 and 30 revolutions per minute. Constant axial force (crowd) shall be applied while rotating the helical piles/anchors into the ground. The crowd applied shall be sufficient to ensure that the helical pile/anchor advances into the ground a distance equal to at least 80% of the blade pitch per revolution during normal advancement. The torsional strength rating of the helical pile/anchor shall not be exceeded during installation.

2) Helical piles/anchors shall be advanced until both of the following criteria are satisfied:

a) Final installation torque is achieved. Final installation torque is as determined by the Engineer, Manufacturer, or pile schedule.

b) Minimum depth is obtained. The minimum depth shall be as shown on the Plans, that which corresponds to the planned bearing stratum, or the depth at which the final installation torque is measured, which-ever is greater.

3) If maximum torque has been reached or augering occurs prior to achieving the minimum depth, contractor shall have the following options:

a) Reverse the direction of torque, back-out the helical pile/anchor a distance of 1 to 2 feet and attempt to reinstall by decreasing crowd and augering through the obstruction.

b) Terminate the installation at the depth obtained subject to the review and acceptance of the Engineer.

c) Remove the helical pile/anchor and install a new one with fewer and/or smaller diameter helical bearing plates. The new helical configuration shall be subject to review and acceptance of the engineer.

d) Remove the helical pile/anchor and pre-drill a pilot hole in the same location and reinstall the anchor/pile. Pilot hole diameter shall match the diameter of the helical pile shaft.

e) If the obstruction is shallow, remove the helical pile/anchor and re-move the obstruction by surface excavation. Backfill and compact the resulting excavation and reinstall the pile/anchor.

f) Remove the helical pile/anchor and sever the uppermost helical bearing plate from the lead section if more than one helical bearing plate is in use, or reshape the helical bearing plates by cutting with a band saw. Reinstall the pile/anchor.

4) If the final installation torque is not achieved at the contract length, the Contractor shall have the following options:

a) Until the maximum depth is achieved, if any, install the helical pile/anchor deeper using additional extension sections.

b) Remove the helical pile/anchor and install a new one with additional and/or larger diameter helical bearing plates.

c) Decrease the rated load capacity of the helical pile/anchor and install additional helical piles/anchors. The rated capacity and additional unit location shall be subject to the review and acceptance of the engineer.

5) If the minimum depth has been obtained but the final installation torque is not achieved due to augering on an obstruction under maximum crowd (refusal):

a) Record "refusal" on installation logs in place of final torque.

b) Submit installation logs to the engineer of record for review and approval.

6) The pile/anchor may be deemed acceptable if one of the following conditions are met:

a) The boring logs indicate suitable bearing stratum at the approximate depth of refusal,

b) Pile capacity is verified by dynamic or static load test. Otherwise, the pile shall be downgraded based on last credible torque reading obtained prior to refusal and additional piles/anchors shall be installed.

4. Micropiles: The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the micropiles. The micropile Contractor shall also determine the micropile casing size, final drillhole diameter and bond length, and central reinforcement steel sizing necessary to develop the specified load capacities and load testing requirements. The micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

a. Drilling: The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services. The drill hole must be open along its full length to at least the design minimum drill hole diameter prior to placing grout and reinforcement. When micropile construction will occur in close proximity to settlement sensitive structures Vibratory pile driving hammers shall not be used or used at the sole discretion of the micropile Contractor. Temporary casing or other approved method of pile drill hole support will be required in caving or unstable ground to permit the pile shaft to be formed to the minimum design drill hole diameter. The Contractor's

proposed method(s) to provide drill hole support and to prevent detrimental ground movements shall be reviewed by the Engineer. Detrimental ground movement is defined as movement which requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

b. Ground Heave or Subsidence: During construction, the Contractor shall observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the Engineer if signs of movements are observed. Contractor shall immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer, the costs of providing corrective actions will be borne by the Contractor.

c. Pipe Casing and Reinforcing Bars Placement and Splicing: Reinforcement may be placed either prior to grouting or placed into the grout – filled drill hole before temporary casing (if used) is withdrawn. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance. The Contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations. Centralizers and spacers (if used) shall be provided at 3 feet centers maximum spacing. The upper and lower most centralizer shall be located a maximum of 5 feet from the top and bottom of the micropile. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. The central reinforcement bars with centralizers shall be lowered into the stabilized drill hole and set. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. Contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion. Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Threaded pipe casing joints shall be located at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, bar splices shall be staggered at least 1 foot.

d. Grouting: Micropiles shall be primary grouted the same day the load transfer bond length is drilled. The Contractor shall use a stable neat cement grout or a sand cement grout with a minimum 28- day unconfined compressive strength of 4,000 PSI. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations. The grouting equipment used shall produce a grout free of lumps and undispersed cement. The Contractor shall have means and methods of measuring the grout quantity and pumping pressure during the grouting operations. The grout pump shall be equipped

with a pressure gauge to monitor grout pressures. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauges shall be capable of measuring pressures of at least 150 PSI or twice the actual grout pressures used, whichever is greater. The grout shall be kept in agitation prior to mixing. Grout shall be placed within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. The grout shall be injected from the lowest point of the drill hole and injection shall continue until uncontaminated grout flows from the top of the pile. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed the grout level is brought back up to the ground level before the next length is removed. The tremie pipe or casing shall always extend below the level of the existing grout in the drill hole. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations. Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout. Grout within the micropiles shall be allowed to attain the required design strength prior to being loaded. If the Contractor elects to use a post-grouting system, Working Drawings and details shall be submitted to the Engineer of Record for review.

e. Grout Testing: Grout within the micropile verification and proof test piles shall attain the minimum required 3-day compressive strength of 2000 PSI prior to load testing. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of pre-production verification test piles and initial production piles. During production, micropile grout shall be tested by the Contractor for compressive strength in accordance with AASHTO T106/ASTM C109 from each grout plant each day of operation or per every 10 piles, whichever occurs more frequently. The compressive strength shall be the average of the 3 specimens tested. Grout consistency as measured by grout density shall be determined by the Contractor per ASTM C 188/AASHTO T 133 or API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat cement grout. Grout samples shall be taken directly from the grout plant. Provide grout cube compressive strength and grout density test results to the Engineer of Record within 24 hours of testing.

f. Micropile Installation Records: Contractor shall prepare and submit to the Engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on the micropile installation log. A separate log shall be provided for each micropile.

g. Pile Load Tests: inspection by the Contractor and Owner's Engineer is needed to assure that each individual micropile is well constructed and to justify load testing only a small number, e.g., 5%, of the total number of production piles installed. Perform verification and proof testing of piles at the locations specified designated by the Engineer. Perform compression load testing in accord with ASTM D1143, tension load testing in accord with

ASTM D3689, and lateral load testing in accord with ASTM D3966, except as modified herein.

3.7 CONCRETE PLACEMENT

A. Ready mix concrete will not be accepted without the inspector receiving the plant dispatch ticket.

B. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Engineer.

D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.

2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

F. Forms: Forms may be made of wood, plywood, metal, or any other material approved by the Engineer. Forms shall be mortar tight, of material strong enough to resist noticeable deflection or bulging between supports, and the interior dimensions of the forms shall be such that the finished concrete shall be of the form and dimensions shown on the Plans. The design of the forms shall take into account the effect of vibration of concrete as it is placed and also the rate of speed at which the forms will be filled. Forms shall be coated with a lubricant as approved by the Engineer. Mechanical vibrators, of an approved type, and continuous spading and/or rodding of concrete shall be used to produce proper contact of concrete with forms and reinforcing steel in piers and with forms and pipe in monolithic inverts insuring a compact, dense and impervious artificial stone of uniform texture.

G. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F for three successive days. Maximum temperature in concrete after placement shall

not exceed 160°F (70°C). Maximum temperature difference between center and surface of placement shall not exceed 35°F (19°C).

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

4. Do not place concrete until the foundation, the adequacy of the forms, the placing of reinforcement and other embedded items have been inspected and approved.

5. Place concrete in daylight unless an approved lighting system is provided.

6. Remove all debris from the interior of forms in preparation for placing concrete. Moisten earth or base course surfaces on which concrete is to be placed immediately before placing concrete. Do not place concrete on excessively wet or frozen surfaces.

7. Place concrete in its final position in the forms within the time stipulated in Sub article 1000-3(E) of NCDOT'S 2024 Standard Specifications for Roads and Structures. Table 1000-2. – Elapsed time shall be measured as the time between adding the mixing water to the mix and placing the concrete. Maximum time in between placing the batches at the work site shall not exceed 20 minutes.

ELAPSED TIME FOR PLACING CONCRETE

Air or Concrete Temperature, whichever is higher.	Maximum Elapsed Time	
	No Retarding Admixture Used	Retarding Admixture Used
90°F or above	30 minutes	1 hr. 15 minutes
80°F through 89°F	45 minutes	1 hr. 30 minutes
79°F or below[A]	60 minutes	1 hr. 45 minutes
70°F through 79°F[B]	60 minutes	1 hr. 45 minutes
69°F or below[B]	1 hr. 30 min	2 hr. 15 minutes

8. Place concrete to avoid segregation of the materials and the displacement of the reinforcement. Thoroughly work the concrete during placement. Bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets or honeycombs.

9. Do not place concrete when the air temperature, measured at the location of the concrete operation in the shade away from artificial heat, is below 35°F unless permission is otherwise granted by the Engineer. When such permission is granted, uniformly heat the aggregates and water to a temperature no higher than 150°F. Place the heated concrete at a temperature of at least 55°F and no more than 80°F.

10. All concrete shall be protected from freezing by the Contractor during the initial 7 days of curing. The Contractor shall submit an anti-freezing plan for review. Frozen concrete shall be removed and replaced at the Contractor's expense.

H. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

I. Finishing: Provide the type of finish required by the contract directly applicable to the work being constructed

1. Ordinary Surface Finish: Remove all form ties or metal spacers to a depth of at least 1 inch below the surface of the concrete and clean and fill the resulting holes or depressions with grout. Metal devices with exposed cross-sectional area not exceeding approximately 0.05 sq. inches on surfaces permanently in contact with earth fill may be broken off flush with the surface of the concrete.

   Remove all fins caused by form joints and other projections. Remove stains and discoloration. Clean all pockets and fill with grout as directed. Thoroughly soak the surface of all concrete with water before the application of a grout repair.

   Use grout consisting of one part cement and two parts sand. Use cement from the same source as originally incorporated in work. Cure the grout for at least 3 days. After the grout has thoroughly hardened, rub the patch with a carborundum stone as required to match the texture and color of the adjacent concrete.

   On surfaces that are to be backfilled or surfaces that are enclosed, the removal of form marks, fins and pockets; the rubbing of grouted areas to uniform color; and the removal of stains and discoloration will not be required.

2. Sidewalk Finish: Strike off fresh concrete and compact until a layer of mortar is brought to the surface. Finish the surface to grade and cross section with a float, trowel smooth and finish with a broom.

3. Rubbed Finish: After the ordinary surface finish has been completed, thoroughly wet and rub the entire surface. Use a coarse carborundum stone or other equally good abrasive to bring the surface to a smooth texture and remove all form marks. Carefully stroke the surface with a clean brush to finish the paste formed by rubbing. Alternatively, spread the paste uniformly over the surface and allow it to take a reset. Finish by floating with a canvas, carpet-faced or cork float or rub down with dry burlap.

4. Float Finish: Finish the surface with a rough carpet float or other suitable device leaving the surface even but distinctly sandy or pebbled in texture.

J. Curing: Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.

   b. Continuous water-fog spray.

c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.

b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

K. Flowable Fill

1. Use straps, soil anchors or other approved means of restraint to ensure correct alignment when flowable fill is used as backfill for pipe or where flotation or misalignment may occur.

2. Protect flowable fill from freezing for a period of 36 hours after placement or until the fill is backfilled.

3. Place flowable fill to the designated fill line without vibration or other means of compaction.

4. Flowable fill may be placed during freezing conditions, provided measures are taken to prevent damage to the concrete until sufficient strength has been attained. Care should be taken to avoid freezing before initial set. Concrete must not be placed during heavy or prolonged precipitation.

5. Take all necessary precautions to prevent any damages caused by the hydraulic pressure of the fill during placement prior to hardening. Provide the means to confine the material within the designated space.

L. Testing: The following tests will be performed by a Testing Laboratory selected by CHARLOTTE WATER to ensure the concrete quality. The costs for performing the tests

will be paid by for by CHARLOTTE WATER when the test results are in conformity with the specifications below. However, those which show no conformity, or a failure will be paid for by the Contractor. It shall be the responsibility of the Contractor to properly inform the Testing Laboratory as to when the concrete will be placed into the forms. For developer projects, the testing laboratory shall be approved by the Engineer, and shall be a sub consultant to the Developer's Consulting Engineer. All cost of testing shall be paid by the developer.

1. Compressive strength in accordance with ASTM C-31 and ASTM C-39. Test cylinders which are formed in the field will be left in the field until compression testing (7-day, 14-day, 28-day) is completed thereby more closely approximately the curing conditions of the field placed concrete.
2. Slump Test in accordance with ASTM C-143.
3. Air Content Test in accordance with either ASTM C-173 or ASTM C-231.
4. A strength test shall be the average of the strengths of at least two 6 x 12 in. cylinders or at least three 4 x 8 in. cylinders made from the same sample of concrete and tested at 28 days or at test age designated for f'c.
5. Cellular concrete unit weight testing shall be in accordance with ASTM C496, ASTM C796 and ASTM C869.
6. The testing agency performing acceptance testing shall comply with ASTM C1077.
7. Samples for preparing strength test specimens of each concrete mixture placed each day shall be taken in accordance with (a) through (c):
    a. At least once a day.
    b. At least once for each 150 CY of concrete.
    c. At least once for each 5,000 SF of surface area for slabs or walls.
8. Engineer shall be consulted if exemption from testing is requested.

3.8 CONNECTIONS TO EXISTING SEWERS

A. Tie-ins to existing activated sewer lines will be allowed when proper precautions are taken to protect the existing main. Tie-ins to existing un-activated sewer lines not installed under the same contract will not be allowed without written approval from all parties involved (CHARLOTTE WATER, contractors, contract holders, etc.). The Contractor will be required to install watertight masonry plugs in the proposed pipeline at the existing manhole and watertight masonry plugs or approved mechanical plugs at the first proposed manhole until all construction and testing is complete. If the proposed sewer does not begin at an existing manhole, a straddle type manhole as shown on the Standard Details will be constructed over (and around) the undisturbed existing pipeline and the proposed pipeline plugged as specified. The existing pipeline will not be cut out and the new invert formed until all testing has been successfully completed.

1. Pre-Cast Manhole Tie-In: Any connection with 18-inch and smaller pipe at an existing precast manhole will require the Contractor to core the necessary opening through the manhole wall. Connections to existing manholes with 20- inch and larger pipe may be cored or sawed as approved by the Engineer. Jackhammer or sledgehammer break-in to the manhole is not permitted. The connection shall be completed with the installation of a watertight manhole/pipe rubber compression

boot in the cored hole. The connection shall be completed with a monolithic concrete invert/shelf/exterior collar in the sawed hole.

2. Brick/Block Manhole Tie-In: Connections to existing brick/block manholes may be cored or sawed for all pipe diameters. Depending on the condition of the existing manhole, CHARLOTTE WATER may require replacement of the manhole. The connection shall be completed with a monolithic concrete invert/shelf/exterior collar in the sawed or cored hole.

3. Manholes Within Floodplain: Contractor shall make provisions to prevent flooding of manholes located within a floodplain when the frame, cover or riser sections are removed during tie-in or bypass pumping. The contractor shall submit a written method/process to the Engineer for review and approval prior to scheduling any work which endangers the existing sewer system.

4. Temporary Watertight Plugs: 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, during lunch breaks, and elsewhere as dictated by good engineering and construction practices. All installed pipe shall be backfilled or otherwise securely tied down to prevent flotation in the event water enters or rises in the trench. The pipe system shall be watertight during any absence of the Contractor from the project site. The plugs as installed shall prevent infiltration or the introduction of any foreign material into either the existing or proposed systems. The City will not accept any pipeline or manhole which contains any silt, sedimentation or other foreign material, within. The Contractor shall at their own expense flush, or otherwise cause the line (and manholes) to be cleaned out without any discharge into the existing system. Upon completion of all construction, the Contractor will be responsible for the complete removal of all watertight plugs, in the sequence necessary to allow testing and subsequent activation, all under the review of the Engineer.

5. Scheduling: 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 appropriate controlling agencies and Engineer and may require night, holiday, and/or weekend work.

3.9 BYPASS PUMPING

A. Bypass Pumping: If pumping is required, an identical standby pump shall be on site in the event of failure of the primary pump. The standby pump shall include its own bypass piping system or shall be connected to the primary bypass piping system, so the standby pump can immediately be placed into service when needed. All pumps shall be sound attenuated to 68 dBA at 23 feet. The bypass pumping system must be continuously monitored by the Contractor at all times bypass pumping is occurring. This includes 24-hour monitoring when no work is being performed. 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 shall be suspended until the problem is resolved to the satisfaction of the Engineer. All bypass pumping and piping operations shall be installed a minimum of 2 feet above the 100-year flood elevation.

B. Plugging or blocking of sewage flows shall incorporate a primary and secondary plugging device for 15” up to 24” diameter pipe. When plugging or blocking is no longer needed

for performance and acceptance or work, it is to be removed in a manner that permits the sewage flow to slowly return to normal without surge, to prevent surcharging or causing other major disturbances downstream.

C. The Contractor shall tie-off and/or anchor temporary plugs used in the bypassing of flow such that plugs are not able to proceed into downstream piping.

D. During any bypass pumping operations, signage and emergency contact information must be clearly visible at the bypass pumping operations site.

E. Sustained bypass pumping operations (operations exceeding 24 hours) will require installation of an auto-dialer, even if the operation is continuously monitored by a person.

F. Contractor shall provide a temporary cast iron or steel cover over the bypass pumping suction manhole and discharge manhole to safeguard the manholes, to prevent inflow and to minimize odors. At the discharge manhole, the Contractor shall route the discharge piping down into the manhole and shall install 90-degree bends on the end of the piping to direct the flow out of the discharge manhole and heading downstream. The piping arrangement shall be such that the flow is not vertically directed. This piping arrangement will help to direct the flow and minimize turbulence (and odors) in the discharge manhole.

G. The Contractor will be required to submit, for approval by the Engineer, a detailed plan of the method the Contractor proposes to maintain the existing flow during construction. The plan must include a provision for handling the existing peak flow by pumping or bypassing by gravity. At a minimum the following items must be included with the submittal:

1. Number of pumps including pump manufacturer data and pump curves. A backup pump(s) must be provided such that the peak bypass flow can be maintained with the largest pump out of service.

2. The primary and standby pumps shall be piped so no changes in piping are required to switch between pumps. Automated controls are required to switch between the primary and standby pump(s).

3. Provisions for manned 24-hour monitoring, as long as bypass pump is in operation.

4. Site plan showing location of bypass pumping operations, suction manholes, discharge manholes, bypass piping layout/alignment and access. The layout shall include the profile, including 100-year flood elevation, the pump elevations, manhole rim elevations, invert elevations, bypass piping profile – on grade or trenched installation.

5. Expected duration of bypass pumping operations.

6. Location and number of proposed tie-off and/or anchors used to prevent movement or blowouts for plugs.

H. Upon approval of the plan, and prior to initiating bypass pumping operations, the Contractor will be required to verify his method of handling sewer flows during construction by pumping at peak flows for four (4) hours for each pump. Testing shall include verification of automated controls, automated switch to standby pump and auto-dialer operations. This test must be witnessed by CHARLOTTE WATER.

I. The Contractor will be required to perform bypass pumping operations during dry weather, unless otherwise authorized by CHARLOTTE WATER.

J. If a failure of bypass pumping operations occurs, the Contractor shall be responsible for any fines levied as a result of effluent reaching creeks and waterways.

K. Flow from all connecting sewers must be accommodated. Bypass piping for connecting sewers 8" to 12" may utilize lay flat hose. Bypass piping for connecting sewers 15" to 24" shall utilize hard piping and must have primary and standby sound-attenuated diesel auto-priming pumps. If connecting to the main bypass discharge line, the connection must have an isolating gate valve.

3.10 DISMANTLEMENT AND ABANDONED SANITARY SEWER SYSTEMS

A. The following requirements shall apply for proposed abandonment of existing facilities unless otherwise shown on the plans or approved by the Engineer. All areas disturbed by abandonment will be restored.

1. Abandonment Of Existing Manholes: Manholes which are to be abandoned will first have both influent and effluent lines plugged inside the manhole with watertight masonry plugs. The manhole invert shall have a minimum 2-inch diameter hole drilled through the base to permanently drain the manhole structure. The manhole will then be filled with non-compressible material (#67 stone or as approved), to a point three feet (3'-0") below the finish grade. The remainder of the manhole shall be broken down and removed. Then the excavation shall be filled to finish grade with suitable soil compacted in place. When an existing manhole to be abandoned is located within 50-feet of a wetland, piping 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 plugs.

2. Abandonment Of Existing Manholes (Within 50-feet of Wetlands): When an existing manhole to be abandoned is located within 50-feet of a wetland, piping 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 plugs. The manhole invert shall have a minimum 2-inch diameter hole drilled through the base to permanently drain the manhole structure. The manhole will then be filled with non-compressible material (#67 stone or as approved), to a point three feet (3'-0") below the finish grade. The remainder of the manhole shall be broken down and removed. Then the excavation shall be filled to finish grade with suitable soil compacted in place.

3. Abandonment Of Mains At Manholes Which Remain In Service: Abandoned mains at active manholes shall be completely removed from the manhole, including the manhole/pipe connector boot. The hole in the manhole shall then be plugged with a watertight masonry plug. When the abandoned pipe connects to the manhole without a rubber boot, the abandoned pipe 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 plugs. The invert shall then be rebuilt to conform with the Standard Details.

4. Abandonment Of Exposed Pipe: Exposed sections of abandoned mains shall be removed to a point not less than 5 feet into the adjacent banks. 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 three feet (3'-0") below the finish grade. Steel piers shall be cut off three feet (3'-0") below finish grade.

5. Abandonment of Sanitary Sewer Services: Dismantlement of sewer services may include but shall not be limited to capping or plugging lateral at main, manhole, and/or at right-of-way. Sewer laterals shall be dismantled according to the following scenarios:

   a. Short side sewer lateral – tap **outside** of pavement, shall be cut at the main/manhole, plugging the main/manhole invert watertight and rebuilding the invert. Lateral shall be cut/plugged watertight at road right-of-way. Dismantled lateral shall be removed from main/manhole to road right-of-way.

   b. Long side sewer lateral – tap **outside** of pavement, shall be cut at the main/manhole, plugging the main/manhole invert watertight and rebuilding the invert. Lateral shall be cut/plugged watertight at road right-of-way. Dismantled lateral shall remain in place below pavement.

   c. Sewer lateral – tap **inside** pavement, shall be cut and plugged watertight at the edge of pavement or back of curb. If the lateral connects to a manhole inside the pavement, the lateral pipe shall be plugged watertight from inside the manhole. The invert shall be rebuilt per the Standard Details. Lateral shall be cut/plugged watertight at road right-of-way. Dismantled lateral shall remain in place below the pavement to the road right-of-way.

   d. Sewer lateral with outside drop structure at manhole located outside pavement - shall be cut at the manhole, removing outside drop structure and plugging the manhole watertight at both pipe penetrations. The lateral invert shall be rebuilt per the Standard Detail. Lateral shall be cut/plugged watertight at road right-of-way. Remove pipe from manhole to road right-of-way for short side laterals. Dismantled lateral shall remain in place below the pavement to the road right-of-way for long side laterals.

   e. Sewer lateral with outside drop structure at manhole located inside pavement - shall be plugged watertight from inside the manhole. The lateral invert shall be rebuilt per the Standard Detail. Lateral shall be cut/plugged watertight at road right-of-way. Invert in manhole and top pipe penetration shall be plugged watertight and the existing tee will be plugged. Dismantled lateral shall remain in place below the pavement to the road right-of-way.

   f. Sewer lateral with inside drop structure in manhole located outside pavement - shall be cut at the manhole, removing inside drop structure and plugging the manhole wall at the top pipe penetration watertight. Lateral shall be cut/plugged watertight at road right-of-way. Remove pipe from manhole to road right-of-way for short side laterals. Dismantled lateral shall remain in place below the pavement to the road right-of-way for long side laterals.

   g. Sewer lateral with inside drop structure in manhole located inside pavement - shall be plugged watertight from inside the manhole after removing the inside drop structure. The lateral invert shall be rebuilt per the Standard Detail. Lateral shall be cut/plugged watertight at road right-of-way. Inside drop structure shall be removed and the manhole wall at the top pipe penetration shall be plugged watertight. Dismantled lateral shall remain in place below the pavement to the road right-of-way.

   h. Sewer laterals inside CHARLOTTE WATER easements – shall be removed from main to easement limits. Plug lateral watertight at easement limits. Plug lateral watertight at main/manhole per bullets above.

i. Inverts shall be reworked to remove abandoned trough when applicable. No open ends of pipe shall be left unplugged, including the private side of the service lateral past the cleanout, if applicable. All pipe cuts must be plugged watertight.

j. Sanitary sewer services to be dismantled may require CCTV work to be performed in the sewer main in order to locate laterals for dismantlement. In an event that the CCTV camera gets stuck or obstructions in the main prevent the camera from progressing, the CCTV camera shall be retracted, and the existing sewer line will need to be cleaned with the appropriate equipment to remove all obstacles for the CCTV.

k. The Engineer may require that sections of the existing sewer main be replaced if the CCTV work performed under this contract deems necessary. The scope of pipe replacement will be determined based off the existing pipe and the Engineer's discretion.

l. Clean outs located inside road right-of-ways shall be removed 3 feet below grade and plugged watertight. Clean outs located outside Road right-of-ways or CHARLOTTE WATER easements shall not require any additional dismantlement.

m. In the event that active shoring is required, the minimum size trench box necessary to perform the dismantlement shall be utilized.

6. Abandonment Of Existing Pump Stations: Pumps, motors, controls, generator, etc., shall be salvaged and transported by the Contractor to the sewer maintenance yard at 3001 Wilmont Road. All influent and effluent pipes shall be plugged with watertight masonry. The pump chamber and wet well (if abandoned) will be filled with non- compressible material (#67 stone or as approved), to a point three feet (3'-0") below the finish grade. The base of the pump chamber and wet well shall have a minimum 2-inch diameter hole drilled through the base to prevent accumulation of water within the abandoned structures and permanently drain the structures. The remainder of the structure shall be broken down and removed. Then the excavation shall be filled to finish grade with suitable soil compacted in place. All above ground structures associated with the pump station, including fencing and the access road shall be removed and the area restored. Water service shall be abandoned as required in the water chapter, and any wells on site shall be abandoned and plugged as required by state code. Overflow containment basin berms shall be removed, and the fill material shall be used to partially fill the basin with flattened slopes to the low side. Access road shall be removed, and all disturbed areas shall be restored.

7. Abandonment within NCDOT Rights-of-Way: utility pipes larger than 24 inches to be abandoned via removing completely or filling with cellular grout or flowable fill to at least 90% full in accordance with NCDOT Standard Specifications for Roads and Structures Section 1530 Abandon or Remove Utilities 1530-3 (A).

3.11 TRACER WIRE, PIPE MARKING, AND IDENTIFICATION

A. The installation of tracer wire is required on all underground pipe, including both sewer and sewer laterals. All sewer pipe, regardless of size or pipe material, shall be installed with a tracer wire.

B. Tracer Wire System: A single conductor AWG No. 12 (12-guage) solid copper wire with 30 mils green HDPE insulation shall be laid on top of the pipe to aid in locating the pipe

for maintenance purposes. The wire shall extend along the entire length of the new pipe installed. The copper conductor wire shall conform to ASTM B-3.

1. The wire shall be secured to the pipe with zip ties or duct tape (2-inches in width) at every pipe crown and at the midpoint of each pipe joint, or at a maximum, every 10 feet. The wire shall be a single continuous conductor from manhole to manhole.

2. When joining two sections of tracer wire a weatherproof, copper alloy crimp connector or split bolt wire shall be used to connect each end, according to the Standard Details. The primary wire shall be a single continuous wire from manhole to manhole. The primary wire along the main shall not be cut to complete a splice for a service lateral. The insulation on the primary wire shall be removed to allow the lateral service tracer wire splice. The splice shall be made watertight with application of multiple overlap layers of rubber tape and finished with multiple overlap layers of vinyl tape, as required in the Standard Details. Splices shall be isolated from direct tension on the wires in accordance with the Standard Details.

3. All vertical tracer wires shall be installed in PVC conduits per the Standard Details.

4. A 24” pigtail will be provided in each manhole, vault, valve box, cleanout, or any structure exposed to daylight, per the Standard Details.

C. Trace Wire for Horizontal Directional Drilling: Install all facilities such that their location can be readily determined by electronic designation after installation. Attach a minimum of two (2) separate and continuous conductive tracking (tone wire) materials, either externally, internally or integral with the product. The ends of the tone wire shall be stubbed up through a one inch (1”) diameter SCH 80 PVC pipe which shall be installed in the concrete valve pad adjacent to the isolation valve box on both sides of the directional drill, or in its own concrete flush mounted underground locator box. Tracer wires shall be solid No. 12 AWG copper coated steel wire with 45 mils green HDPE insulation. Conductors must be located on opposite sides when installed externally. Conductor ends must be stubbed out through the PVC conduit at the isolation valve box at the terminus of the drill.

D. Tracer Wire Testing

1. Contractor shall perform post installation testing of the tracer wire system to confirm conductivity from manhole to manhole and sewer laterals on a daily basis during construction. Immediately prior to, or during the final inspection, the Contractor shall perform post installation testing of the tracer wire system to confirm conductivity from manhole to manhole and sewer laterals. Test tracer wire for continuity, in presence of Engineer during the final inspection or when approved by the Engineer.

2. Notify Engineer in writing 5 working days in advance to schedule testing.

3. Tracer wire installation shall allow for proper access for connection of line tracing equipment and allow for proper locating of wire without loss or deterioration of low frequency signal.

4. If test for continuity is negative, repair or replace as necessary to achieve continuity. The repair or replacement of any defective or improperly installed systems shall be the responsibility of the Contractor. Any and all repairs or replacement of defective or improperly installed tracer wire systems shall be performed by the Contractor and at no cost to the Engineer. Method of repairs or replacement shall be subject to the approval of the Engineer.

5. Approved Testing Equipment:
    a. Fluke Networks PRO3000 Tone Generator and Probe Kit
    b. Pre-Approved Equal

E. Sewer Warning Tape: 6-inch wide green and black warning tape will be installed 12 inches above the top of all mainline sewer pipe and sewer laterals, and 24 inches below finish grade.

1. Warning tape shall be buried in the backfill approximately one foot below grade, directly over the top of the PVC or HDPE pipeline. Tape shall be laid in continuous lengths. Any breaks or tears shall be repaired before proceeding with the backfilling operations.

3.12 GRAVITY SEWER AND MANHOLE TESTING

A. Sewer Lines and Manholes: The Contractor shall provide proper ventilation of sewer lines and manholes during any test or inspection procedure. The Contractor shall be responsible for providing all equipment and personnel necessary to comply with OSHA confined spaces regulations.

B. The Contractor shall PRETEST the gravity sewer system as indicated below prior to requesting official tests. The Contractor shall advise the Engineer of any problem areas. Repairs shall be made with the knowledge and approval of the Engineer. Methods of repairs shall be subject to approval of the Engineer. Infiltration into manholes and pipe shall be corrected prior to required testing of manholes and pipe. Once all required pre-testing has been successfully completed, the Contractor will schedule the official test with the Engineer. All official tests shall be conducted under the direct inspection, review and approval of the Engineer. All testing procedures shall be verified and witnessed by the Engineer.

C. The following quality control tests are required prior to acceptance and activation of gravity sewer systems:

1. For Pipe:
    a. Infiltration and Internal Inspection,
    b. Deflection,
    c. Low Pressure Air Test (Manhole to Manhole), or,
    d. Low Pressure Air - Pipe Joint Test,
    e. Hydrostatic Test (Manhole to Manhole), when within 100 feet of a well, or when specified,
    f. Internal Visual Inspection (Joint by Joint), when specified,
    g. Internal CCTV Inspection (MH to MH and Laterals).
2. For Manholes and Wet wells:
    a. Infiltration Inspection
    b. Internal Inspection
    c. Vacuum Test
    d. Exfiltration (Water) Test

e. Zero Leakage Hydrostatic Test

3. Trace Wire Conductivity Test

D. ALL TESTING SHALL BE COMPLETED IN THE FINAL 30 DAYS PRIOR TO ACTIVATION OR ACCEPTANCE BY CHARLOTTE WATER, EXCEPT PIPE JOINT TESTING PERFORMED AT THE TIME OF INSTALLATION.

E. Gravity Sewer Pipe Leakage Testing: No sooner than 10 days following completion of backfill, the Contractor along with the project inspector will be required to determine the level of the ground water table. The ground water table elevation shall be noted on the plans relative to the top of the pipe. The sewer line shall be inspected and tested for infiltration. Regardless of the ground water table elevation, all gravity sewer mains shall be tested by Low Pressure Air – manhole to manhole, or individual joint test by low pressure air or low pressure water. Each test shall be performed as follows:

1. Infiltration: Each manhole and section of pipe shall be visually inspected. The allowable leakage shall be 0.0 gallons. Weir measurements will not be necessary. Any visible point of infiltration or leak, or any flow of water in the pipe invert will constitute failure of the test. Any failed section of pipe or manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each pipe section and manhole has passed the official test.

2. Low Pressure Air Test (Manhole to Manhole)

a. The low-pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is over-pressurized or plugs are installed improperly. It is extremely important that the various plugs be installed so as to prevent the sudden expulsion of a poorly installed or partially inflated plug.

b. Tests shall be performed in accordance with ASTM F-1417 (Plastic Gravity Sewer Pipe – PVC), regardless of pipe material, and as modified below. Low pressure air tests shall be performed on sewer lines 24-inches in diameter and smaller. The test method shall be the Time-Pressure Drop Method as indicated in the standards and as modified below. Test pressure will be measured by gauges furnished by CHARLOTTE WATER and installed by the Contractor above ground at the manhole opposite the air supply. The Contractor shall furnish all other test equipment required including connecting hoses at the CHARLOTTE WATER supplied gauge.

c. Required Test Time:

1) Determine the Main Test Time (T_M), Lateral Test Time (T_L), Total Test Time (T_T), Minimum Test Time (T_m) and the Required Test Time (T_R):

2) $T_M = T1 \times L$, where:

a) T_M = Main Test Time, Seconds,

b) T1 = Constant as indicated in table below, based on Main Diameter,

c) L = Length of Main, feet.

3) $T_L = T2 \times n$, where:

a) T_L = Lateral Test Time, Seconds,

b) T2 = Constant as indicated in table below, based on lateral Diameter,

c) n = Number of laterals included in the test section, each.

4) $T_T = T_M + T_L$, where:

a) T_T = Total Test Time, Seconds,

5) T_m = T3, where:

a) T_m = Minimum Test Time, Minutes and Seconds,

b) T3 = Constant as indicated in the table below.

6) $T_R = T_T$ or T_m , compare T_T and T_m , and use whichever is greater, where

a) T_R = Required Test Time, to be used in the Low Pressure Air Test.

Pipe Diameter, D - inches	1.0 PSI Test T1 – Main Test Time – Seconds	1.0 PSI Test T2 – Lateral Test Time - Seconds	1.0 PSI Test T3 - Minimum Test Time - Minutes: Seconds
4	n/a	12.0	n/a
6	n/a	26.0	n/a
8	1.520	n/a	7:34
10	2.374	n/a	9:26
12	3.418	n/a	11:20
15	5.342	n/a	14:10
16	6.038	n/a	15:10
18	7.692	n/a	17:00
20	9.418	n/a	19:00
21	10.470	n/a	19:50
24	13.674	n/a	22:40

7) When approved by the Engineer, 15-inch diameter and larger mains may be tested by the 0.5 PSI Time-Pressure Drop Method in lieu of the 1.0 PSI Time-Pressure Drop Method. The 0.5 PSI Test may only be used when the Contractor requests the 0.5 PSI Test, and the Required Test Time (T_R), as determined above, is greater than 30 minutes. When the 0.5 PSI Test has been approved by the Engineer, the Required Test Time (T_R) shall be determined based on the equations above, and the table below:

Pipe Diameter, D - inches	0.5 PSI Test T1 – Main Test Time – Seconds	0.5 PSI Test T2 – Lateral Test Time - Seconds	0.5 PSI Test T3 - Minimum Test Time - Minutes: Seconds
4	n/a	6.0	n/a
6	n/a	13.0	n/a
8	n/a	n/a	n/a
10	n/a	n/a	n/a
12	n/a	n/a	n/a
15	2.671	n/a	7:05
16	3.019	n/a	7:35
18	3.846	n/a	8:30
20	4.709	n/a	9:30
21	5.235	n/a	9:55
24	6.837	n/a	11:20

d. Required Test Pressure:

1) The Contractor along with the project inspector will be required to determine the level of the ground water table. The ground water table elevation shall be noted on the plans relative to the top of the pipe at the upstream end of each section of pipe.

2) Since water produces a pressure of 0.43 PSI for every foot of depth, the required air test pressure shall be increased to offset the depth of ground water over the sewer main. If the ground water level is 2 ft or more above the top of the pipe at the upstream end, or if the air pressure required for the test is greater than 9 PSI, the air test method shall not be used until the ground water level is lowered by pumping or dewatering.

3) The minimum required starting test pressure shall be 3.5 PSI. When ground water is present, the required starting test pressure shall be increased as indicated below. The maximum required starting test pressure shall be 9.0 PS.

4) Determine the Require Starting Pressure (P_T) and the Stabilization Pressure (P_S):

5) $P_W = (E_W – E_I) \times 0.43$, where

   a) P_W = Pressure increase due to ground water table elevation, PSI,

   b) E_W = Elevation of water table, feet,

   c) E_I = Elevation of pipe invert at downstream manhole, feet.

6) $P_T = P_M + P_W$, but less than 9.0 PSI, where:

   a) P_T = Required Starting Test Pressure, PSI,

   b) P_M = Minimum Required Starting Test Pressure = 3.5 PSI,

   c) P_W = Pressure increase due to ground water table elevation, PSI.

7) $P_S = P_T + 0.50$, where:

a) P_S = Stabilization Pressure, PSI

e. Low Pressure Air Test Procedure

1) Observe the Following Safety Precautions:

a) Personnel shall NOT be allowed in the manholes during testing because of the hazards.

b) Plugs and cleanouts shall be securely installed and braced in such a way as to prevent blowouts.

c) When mains are to be tested, the plugs and cleanouts shall be braced as an added safety factor.

d) Do not over-pressurize the lines. It is also imperative that the pressure in the pipe be relieved completely before any plug is loosened for removal.

e) Pressurizing equipment shall include a 9-psi pressure relief valve or regulator to prevent over-pressurization and possible damage to the main.

f) Personnel shall NOT be allowed in the manholes or within ten (10) feet of the manholes during pressurization, testing, or depressurization.

2) Preparation of the Sewer Main and Test Procedure:

a) Clean the section of sewer main to be tested by flushing or other means prior to conducting the low-pressure air test. This cleaning serves to eliminate debris and produce the most consistent results.

b) Isolate the section of sewer main to be tested by inflatable plugs, mechanical test plugs or other suitable test plugs.

c) Plug or cap the ends of all branches, laterals, cleanouts, tees, and stubs to be included in the test to prevent air leakage. All plugs and caps shall be securely braced to prevent blow-out. The plug at each manhole shall have an inlet tap, or other provision for connecting a hose.

d) Connect the air hose to the inlet tap and portable air control source. The air equipment shall consist of necessary valves and pressure gauges to control an oil-free air source and the rate at which air flows into the test section to enable monitoring of the air pressure within the test section.

e) Connect the air hose to the inlet tap at the manhole opposite the portable air control source. The 15 PSI gauge shall be furnished by the Engineer and connected to the hose. The gauge shall be positioned a minimum of 10 feet away from the manhole.

f) Add air slowly to the test section until the pressure inside the pipe reaches the stabilization pressure (PS), equal to the required test pressure (PT) plus 0.5 PSI.

g) After the stabilization pressure is obtained, regulate the air supply so that the pressure is maintained within 0.5 PSI of the stabilization pressure for at least 2 minutes. The stabilization period will vary, depending on air/ground temperature conditions. The air temperature should stabilize in equilibrium with the temperature of the pipe walls. The pressure will normally drop slightly until equilibrium is obtained; however, the pressure shall be maintained within 0.5 PSI of the stabilization pressure.

h) When the pressure has remained stable for 2 minutes, disconnect the air supply and slowly decrease the pressure to the required test pressure (PT) before starting the test.

i) Record the starting test pressure and the starting time, and begin the timed test.

j) Monitor the pressure gauge to determine the rate of air/pressure drop by the time-pressure drop method.

k) Monitor the pressure gauge and the clock until the end of the required test time (TR) period.

l) Record the ending test pressure and the ending time.

m) For the 1.0 PSI Time-Pressure Drop Test, the section of main shall pass the test if the pressure drop is less than one (1.0) PSI at the end of the required test (TR) period. The section of main shall fail the test if the pressure drop is greater than one (1.0) PSI at the end of the required test time (TR) period.

n) For the 0.5 PSI Time-Pressure Drop Test, the section of main shall pass the test if the pressure drop is less than one half (0.50) PSI at the end of the required test (TR) period. The section of main shall fail the test if the pressure drop is greater than one half (1.0) PSI at the end of the required test time (TR) period.

o) Upon completion of the test, open the bleeder valve and allow all air to escape. Plugs shall not be removed until all air pressure in the test section has been reduced to atmospheric pressure.

p) If the main fails the test, segmented testing may be utilized solely to find the location of leaks. Once leaks are located and repaired, retest the completed pipe installation to requirements of this test method.

f. Any failed section of pipe shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each pipe section has passed the official test.

g. Sewer lines larger than 24-inches in diameter shall be tested for infiltration as specified above. Each joint shall be individually tested by low pressure air or water as specified below. Each joint shall also be visually inspected by a CHARLOTTE WATER representative as specified below.

3. <u>Low Pressure Air – Pipe Joint Test (Individual Joint Test)</u>

a. Sewer mains 30-inch and larger shall be tested by the Low Pressure Air - Pipe Joint Test. The use of compressed air is dangerous if a sewer line is not prepared properly, and proper procedures are not followed. It is imperative that all pressures be relieved completely before the test apparatus is loosened for removal. Pressurizing lines for the two end element sealing tubes shall be separate from the lines for pressurizing the void volume created by the joint test apparatus. The pressures required to seal the end element tubes shall be as specified by the apparatus manufacturer, and are greater than the pressure required to test the joint. The line for pressurizing the void volume shall include a 6-psi pressure relief valve to reduce hazards and avoid over-pressurization.

b. Tests shall be performed in accordance with ASTM C 1103 (Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines), regardless of pipe material, and as modified below. Test pressure will be measured by gauges furnished by CHARLOTTE WATER and installed by the Contractor a safe distance away from the test joint, the testing equipment and the air supply. The Contractor shall furnish all other test equipment required including connecting hoses at the CHARLOTTE WATER supplied gauge.

c. The Contractor shall test joints of installed sewer pipe, regardless of pipe material, with air to demonstrate the integrity of the joint. Joints shall be tested after backfilling, and without any groundwater effect. Assuming the backfilling operations has covered approximately one-half the last joint of pipe installed, the joint to be tested will be the third joint from the open bell of the last joint installed. After each joint has been installed and before the joint test, all joints shall be tested with a feeler gauge supplied by the pipe manufacturer to determine if the joint gasket has been properly seated.

d. Joint testing apparatus, including an air compressor and hose, shall be furnished by the Contractor and shall be as manufactured by Cherne Industries Incorporated, or approved equal. The joint tester end element sealing tubes when inflated shall create an airtight seal over the joint of the pipe. Inflate end element sealing tubes with air in accordance with the equipment manufacturer's instructions.

e. The center cavity between the end elements shall be pressurized with air to 3.5 PSI. Pumps, dewatering equipment or wellpoint systems shall be used to maintain the ground water elevation a minimum of 6 inches below the bottom of the pipe.

f. If the pressure in the cavity holds or drops less than 1 PSI in 5 seconds, the pipe joint shall be found to be acceptable. If the pressure drop is greater 1 PSI in 5 seconds, the joint is defective and shall be disassembled and remade or repaired and retested.

g. Testing of pipe joints shall be performed immediately after installing and backfilling the next pipe section. The test operator shall keep a log of all tests showing the following.

    1) Joint number from specific numbered manholes.

    2) Date and time.

    3) Name of test operator.

4) Sealing pressure used.

5) Joint test pressure used.

6) Number of seconds joint held pressure to 1 psig drop.

7) Whether joint passed or failed.

8) Action taken if failure occurred, including retesting.

9) Contractor shall schedule and notify the inspector prior to testing each joint.

h. The Contractor shall use the form provided by the Engineer to log all test data.

i. The Contractor shall submit his plan for joint testing to the Engineer for review at least ten days before starting installation of pipe. Any damage to the pipe from testing shall be repaired by the Contractor.

j. Low Pressure Air-Joint Test Procedure:

1) Observe the Following Safety Precautions:

a) The use of compressed air is dangerous if a sewer line is not prepared properly, and proper procedures are not followed.

b) It is imperative that all pressures be relieved completely before the test apparatus is loosened for removal.

c) Pressurizing lines for the two end element sealing tubes shall be separate from the lines for pressurizing the void volume created by the joint test apparatus. The pressures required to seal the end element tubes shall be as specified by the apparatus manufacturer, and are greater than the pressure required to test the joint. The line for pressurizing the void volume shall include a 6-psi pressure relief valve to reduce hazards and avoid over-pressurization.

2) Preparation of the Pipe Joint and Test Procedure:

a) Clean the joint and interior joint surfaces to eliminate debris prior to wetting and testing.

b) Attach the CHARLOTTE WATER furnished gauge and locate a safe distance away from the test joint, test equipment, and compressed air supplies.

c) Verify the groundwater conditions surrounding the sewer line to be tested are below the pipe.

d) Review proper operation, safety, and maintenance procedures as provided by the manufacturer of the joint test apparatus.

e) Move the joint test apparatus into the sewer line to the joint to be tested and position it over the joint. Make sure the end element sealing tubes straddle both sides of the joint and the hoses are attached.

f) Inflate end element sealing tubes with air in accordance with equipment and manufacturer’s instructions.

g) An air or water reservoir shall be included in the joint test system. By maintaining a constant supply of air in a reservoir, continuous pumping of air or water is not required, and any variances in test equipment and joint space will be negated. The reservoir shall have a minimum volume of 2.5 cubic feet.

h) Pressurize the void volume with air to 3.5 PSI. Allow the air pressure and temperature to stabilize for approximately 15 seconds before shutting off the air supply, and start of test timing.

i) If the joint being tested holds pressure, or drops less than 1 PSI in 5 Seconds, the joint is acceptable.

j) If the joint being tested drops more than 1 PSI in 5 Seconds, the joint fails, it shall be retested. If the retest fails, the pipe joint shall be removed and replaced in a manner approved by the Engineer.

k) After the joint test is completed, slowly exhaust void volume of air, then slowly exhaust end element tubes prior to removal of apparatus.

l) A passing test by the low pressure air - joint test method shall not preclude rejection of the work if groundwater infiltration subsequently occurs at the joint. The required standard is zero leakage at the joint.

k. Any failed pipe joint shall be removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each pipe section has passed the official test.

4. <u>Hydrostatic Test (Manhole to Manhole)</u>

a. When specified, or when any of the pipe is located within 100 feet of a public or private well, the pipe section shall be tested manhole to manhole according to the Hydrostatic Test requirements indicated below. The test section will consist of one upstream manhole and the downstream section of pipe. Vents connected to the manhole shall be included in and tested as part of the manhole. Laterals connected to the manhole shall be included in and tested as part of the manhole. Laterals connected to the pipe shall be included in and tested as part of the pipe. The Hydrostatic Test shall be in addition to the Low Pressure Air Test or the Low Pressure Air – Pipe Joint Test specified above. The low pressure air test methods will be used as an indicator test to determine if there is a leak in the pipe before the Hydrostatic Test is performed.

b. Installation Requirements:

1) Two rows of Butyl Sealant shall be used at all joints (manhole, grade rings, and frame), as specified.

2) All manhole frame and covers located within 100 feet radius of a public or private well shall be solid watertight covers with gasket and camlocks, as specified.

3) Exterior joint wrap sealant shall be used on all manhole joints, as specified.

4) The manhole included in the test section shall be vacuum tested for ten minutes to seat the joints on assembly prior to or after backfilling around manhole, as specified.

5) The inside of any concrete grade rings shall be coated with hydraulic cement grout to make the grade ring watertight.

6) Construct and/or verify that all sanitary sewer mainline pipe and service laterals within 100 feet of a public or private well are constructed with ductile iron pipe only.

7) Construct and/or verify that the ends of each service laterals and cleanouts are properly plugged and restrained (no concrete blocking) to prevent leakage during the test and prevent a plug from blowing out due to hydrostatic pressure.

c. Testing Procedure:

1) Prior to performing hydrostatic test, confirm that no customers/property owners have connected their private plumbing to the service lateral connection.

2) Verify the pipe plugs to be used are rated at a higher pressure rating than expected during the test, due to the height of water in the manhole.

3) The Test Section shall consist of one upstream manhole and one downstream pipe segment.

4) Install a pipe plug in the Flowline In Pipe at the downstream manhole, and brace the plug to prevent movement.

5) Install a pipe plug in the Flowline In Pipe at the upstream manhole, and brace the plug to prevent movement. This includes the upstream manhole in the test segment.

6) Lateral service connections at manhole shall not be plugged. All lateral service connections to the pipe segment and connected to the manhole shall be included in the test.

7) Slowly fill the pipe segment and the upstream manhole until the water level in the upstream manhole is within 1.5-inches of the top of the cast iron frame. Release any trapped air in lateral cleanouts. Refill and note the water level in the frame, and allow the test section to saturate for a minimum of 24 hours.

8) After the 24-hour saturation period, observe and note water level in the upstream manhole.

9) If no drop in water level has occurred during this initial 24-hour period, return after two additional hours and observe and note water level. If no drop in water level has occurred after this two-hour period, the test will be considered successful.

10) If after two hours there has been a drop in the water level, the amount of drop will be noted. Refill the manhole to the initial water level, within 1.5-inches of the top of the cast iron frame. Note the water level.

11) The above sequence of fill and monitor will continue until the water level in the manhole has been maintained at the starting water elevation for two consecutive hours. When the water level remains unchanged (no drop in elevation) for a two-hour period, the test will be considered successful.

12) If after the fourth hour it is determined that the water level cannot be maintained without dropping, the test will be terminated and considered failed.

13) Necessary repairs and/or improvements will be made to the pipe or manhole. Repairs shall be made with the knowledge of, and in a manner approved by the Engineer.

14) Upon completion of remedial actions, the system shall be retested from the beginning, as indicated above.

15) If during the previous four hours, the water level drop has been at a diminishing rate, the contractor may choose to continue the fill and monitor sequence until the water level has been maintained at the same level for two consecutive hours.

d. The contractor may choose to test the pipe and the manhole separately as independent tests. When testing the manhole, laterals connected to the manhole shall be included in, and tested with the manhole. The manhole shall be tested according to the Test Procedure above, except the pipe plugs shall be installed in the upstream and downstream mainline pipes to isolate the test manhole.

e. When testing the mainline pipe segment between two manholes, laterals connected to the pipe shall be included in and tested with the pipe. The pipe segment shall be isolated by plugging the pipe where it enters the upstream and downstream manholes. The lateral cleanout nearest the upstream manhole will be extended to the elevation of the upstream manhole's rim elevation. The pipe segment shall be tested according to the Test Procedure above, except the cleanout shall be used to fill the pipe with water, and water level measurements shall be made at the clean out.

f. When a lateral cleanout is not located in the test section, or near the upstream manhole, the plug at the upstream manhole shall include a pass through tap. A 2-inch diameter standpipe shall be connected to the tap in the plug. The standpipe shall extend to within 1.5-inches of the top of the cast iron frame. The pipe segment shall be tested according to the Test Procedure above, except the standpipe shall be used to fill the main with water, and water level measurements shall be made at the standpipe.

g. Any failed section of pipe or manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each test section has passed the official test.

F. Manhole Leakage Testing: All manholes shall be subjected to a visual infiltration inspection as specified. All newly constructed manhole leakage testing shall take place before the application of any lining or coating systems. ALL manholes installed on the

project shall be tested by either the exfiltration method or vacuum air method, as described herein. At the direction of the Engineer all manholes which may have the potential to surcharge in the event of a lift station failure or backup, shall be tested by the exfiltration method. Manholes shall be tested by plugging the mainline inlet and outlet pipes with airtight plugs and using one of the following procedures: All newly constructed straddle manholes on existing pipe shall be tested prior to cutting out and removing the existing pipe inside the manhole. Laterals connected to the manhole shall be included in and tested as part of the manhole. Vents connected to the manhole shall be included in and tested as part of the manhole. The Vacuum Air Test procedure shall be used to seat the manhole sections, compress the butyl rubber joint sealant, and verify that the manhole should not infiltrate or leak groundwater into the manhole. The Exfiltration Test shall be used to verify that the manhole is watertight and should not leak sanitary sewer into the groundwater. CHARLOTTE WATER testing has confirmed that both tests are required to reasonably confirm that a manhole will not infiltrate or exfiltrate. Therefore, each manhole will be tested by both methods.

1. Infiltration: Each manhole shall be visually inspected. The allowable leakage shall be 0.0 gallons per day. Weir measurements will not be necessary. Any visible point of infiltration or leak, or any flow of water in the manhole invert will constitute failure of the test. Any failed manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge of and the approval of the Engineer. Upon completion of remedial actions, the infiltration inspection procedures shall restart from the beginning. Each manhole shall pass the official test.

   A passing test during the infiltration inspection shall not preclude rejection of the work if groundwater infiltration subsequently occurs at the manhole. The required standard is zero leakage at the manhole until the end of the warranty period.

2. Exfiltration

   a. All newly constructed manholes shall be subjected to an exfiltration test as specified below. Manholes located within 100 feet of a public or private well are exempt from the Exfiltration Test, but pass the Hydrostatic Test (Manhole to Manhole) specified herein, or the Hydrostatic Test (Manhole), specified herein. Vents connected to the manhole shall be included in and tested as part of the manhole. Laterals connected to the manhole shall be included in and tested as part of the manhole. All manholes installed on the project are to be tested. Projects that include lift station rehabilitation or replacement shall have exfiltration testing performed on any existing manhole directly upstream of the lift station wet well. Manholes that fail the test shall be repaired as specified and retested until they pass.

   b. Summary of Practice

      1) Fill the manhole to within 1.5-inches of the top of the cast iron frame with water and allow the level to equalize due to saturation.

      2) Refill the manhole and mark the level to begin the test. The test shall last at least 2 hours and allowable leakage shall be 3 gallons per hour.

   c. Installation Considerations

      1) The manhole vacuum test shall be completed prior to this test procedure.

2) All manholes located outside 100 feet radius of a public or private well shall be tested to this standard, as specified.

3) Construct and/or verify that the ends of each service laterals and cleanouts are properly plugged and restrained (no concrete blocking) to prevent leakage during the test and prevent a plug from blowing out due to hydrostatic pressure.

d. Testing Procedures

1) Prior to performing exfiltration test, confirm that no customers/property owners have connected their private plumbing to the service lateral connection.

2) Verify the pipe plugs to be used are rated at a higher pressure rating than expected during the test, due to the height of water in the manhole.

3) Install a pipe plug in the mainline pipes on the upstream and downstream sides of the manhole and brace the plugs to prevent movement.

4) Lateral service connections at manhole shall not be plugged. All lateral services connected to the manhole shall be included in the test.

5) Vent pipes connected to the manhole shall not be plugged. Vent pipes connected to the manhole shall be included in the test.

6) Fill the manhole until the water level in the manhole is within 1.5-inches of the top of the cast iron frame. Release any trapped air in lateral cleanouts. Refill and note the water level in the frame, and allow the test section to saturate for a minimum of 24 hours.

7) After the 24-hour saturation period, observe and note water level in the manhole.

8) If no drop in water level has occurred during this initial 24-hour period, return after two additional hours and observe and note water level. If the water level drop is less than 3 gallons per hour, after this two-hour period, the test will be considered successful.

9) If after two hours there has been a drop greater than 3 gallons per hour in the water level, the amount of drop will be noted. Refill the manhole to the initial water level, within 1.5-inches of the top of the cast iron frame. Note the water level.

10) The above sequence of fill and monitor will continue until the water level drop in the manhole is less than 3 gallons per hour for two consecutive hours. When the water level drop diminishes to less than 3 gallons per hour for a two-hour period, the test will be considered successful.

11) If after the fourth hour it is determined that the water level drop is not within the allowable, the test will be terminated and considered failed.

12) Necessary repairs and/or improvements will be made to the manhole. Repairs shall be made with the knowledge of, and in a manner approved by the Engineer.

13) Upon completion of remedial actions, the manhole shall be retested from the beginning, as indicated above.

14) If during the previous four hours, the water level drop has been at a diminishing rate, the contractor may choose to continue the fill and monitor sequence until the water level drop is within the allowable leakage for two consecutive hours.

e. Any failed manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each manhole has passed the official test.

3. Vacuum Test – (Negative Air Pressure)

a. Manhole vacuum testing shall be performed in accordance with ASTM C-1244, and as modified below. The steel test plate head shall be placed on the top surface of the manhole frame. Test heads that seat inside the frame/grade ring/manhole cone section are prohibited. All manholes installed on the project shall be tested. Manholes that fail the test shall be repaired as specified or as approved by the Engineer and retested until they pass. Repairs shall be made with the knowledge and approval of the Engineer.

b. The minimum test time shall be as determined in the table below, based on manhole diameter and manhole depth. Actual manhole depth shall be rounded up to the next 2-foot increment. When flat slab transitions are used to reduce the upper portion of a large diameter manhole to a smaller diameter manhole, the Test Time for the manhole shall be determined by:

1) $T_T = T_D + T_d$, where:

a) T_T = Minimum Total Test required for the manhole, Seconds,

b) T_D = Test Time as indicated in table below, based on the manhole diameter below the transition slab and the manhole height below the manhole slab, Seconds.

c) T_d = Test Time as indicated in table below, based on the manhole diameter above the transition slab and the manhole height above the manhole slab, Seconds.

Minimum Test Times for Various Manhole Diameters							
Manhole Depth, Feet	Manhole Diameter, Feet						
	4	5	6	7	8	10	12
	Test Time, Seconds						
4	10	13	16	19	22	28	34
6	15	19	24	29	33	42	52
8	20	26	32	38	44	57	69
10	25	32	40	48	55	71	86
12	30	39	48	57	66	85	103
14	35	45	56	67	77	99	121
16	40	52	64	76	88	113	138
18	45	58	72	86	100	127	155
20	50	65	80	95	111	141	172
22	55	71	88	105	122	156	189
24	60	78	96	114	133	170	207
26	65	84	104	124	144	184	224
28	70	91	112	133	155	198	241
30	75	97	120	143	166	212	258
32	80	104	128	152	177	226	276
34	85	110	136	162	188	240	293
36	90	117	144	171	199	254	310
38	95	123	152	181	210	269	327
40	100	130	160	191	221	283	345
42	105	136	168	200	232	297	362
46	114	149	184	219	254	325	396
48	119	156	192	229	265	339	413
50	124	162	200	238	276	353	431

c. Summary of Practice

1) A vacuum will be drawn, and the vacuum drop over a specified time period is used to determine the acceptability of the manhole.

d. Preparation of the Manhole

1) Verify the manhole has been subjected to the vacuum time required to seat the manhole joints, as specified.

2) If any manhole section includes lifting holes, they shall be plugged watertight with non-shrink grout.

3) All mainline pipes entering the manhole shall be temporarily plugged watertight/airtight, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole.

4) Service lateral pipes entering the manhole shall not be plugged. The service lateral pipe shall be included in the test. Verify lateral and cleanout are properly plugged watertight/airtight, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole/pipe.

5) Vent pipes entering the manhole shall be temporarily plugged watertight/airtight at the vent snout above the 100-year flood elevation. Care shall be taken to securely brace the plug to prevent it from being drawn into the vent.

e. Vacuum Test Procedure

1) The plate test head shall be placed at the top of the manhole frame in accordance with the manufacturer's recommendations. The test head shall compress against the top edge of the cast iron frame such that all joints (manhole, grade rings, frame, pipe and laterals) in the manhole are subjected to the test vacuum. Test heads that seat inside the frame/grade ring/manhole cone section are prohibited from use.

2) A vacuum of 10-inches Hg (mercury) [or 5.0 PSI negative air pressure] shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time shall be measured for the vacuum to drop to 9--inches Hg (mercury) [or 4.5 PSI negative air pressure].

3) The manhole is acceptable if the time needed for the vacuum reading to drop from 10-inches Hg to 9-inches Hg [or from 5.0 PSI negative air pressure to 4.5 PSI negative air pressure] meets or exceeds the Minimum Test Time indicated in the Table and or Equation above.

4) If the manhole fails the initial test, the manhole shall be repaired by an approved method and with the knowledge of the Engineer.

5) Upon completion of remedial actions, the manhole shall be retested until a satisfactory test is obtained.

6) A passing test by the vacuum test procedure shall not preclude rejection of the work if groundwater infiltration subsequently occurs at the manhole. The required standard is zero leakage at the manhole until the end of the warranty period.

7) Any failed manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each manhole has passed the official test.

4. Hydrostatic Test (Manhole)

a. When specified, or when the manhole is located within 100 feet of a public or private well, the manhole shall be tested according to the Hydrostatic Test requirements indicated below, unless included in a Hydrostatic Test (Manhole to Manhole) as indicated above. Laterals connected to the manhole shall be included in and tested as part of the manhole. The Hydrostatic Test shall be in addition to the Vacuum Test (Negative Air Pressure) specified above. The vacuum test method will be used as an indicator test to determine if there is a leak in the manhole before this Hydrostatic Test is performed.

b. Installation Considerations

1) Two rows of Butyl Sealant shall be used at all joints (manhole, grade rings, and frame), as specified.

2) All manhole frame and covers located within 100 feet radius of a public or private well shall be solid watertight covers with gasket and camlocks, as specified.

3) Exterior joint wrap sealant shall be used on all manhole joints, as specified.

4) The manhole shall be vacuum tested for ten minutes to seat the joints on assembly prior to or after backfilling around manhole, as specified.

5) The inside of any concrete grade rings shall be coated with hydraulic cement grout to make the grade ring watertight. Rubber and Expanded Polypropylene (EPP) grade rings may be used in place of concrete grade rings.

6) Construct and/or verify that all sanitary sewer mainline pipe and service laterals connected to the manhole, and within 100 feet of a public or private well, are constructed with ductile iron pipe only.

7) Construct and/or verify that the ends of each service laterals and cleanouts are properly plugged and restrained (no concrete blocking) to prevent leakage during the test and prevent a plug from blowing out due to hydrostatic pressure.

c. Testing Procedure

1) Prior to performing hydrostatic test, confirm that no customers/property owners have connected their private plumbing to the service lateral connection.

2) Verify the pipe plugs to be used are rated at a higher pressure rating than expected during the test, due to the height of water in the manhole.

3) The Test Section shall consist of one manhole and any lateral connected to the manhole.

4) Install pipe plugs in the Flowline In Pipe and the Flowline Out Pipe, and brace the plugs to prevent movement.

5) Lateral service connections at manhole shall not be plugged. All lateral services connected to the manhole shall be included in the test.

6) Fill the manhole until the water level in the manhole is within 1.5-inches of the top of the cast iron frame. Release any trapped air in lateral cleanouts. Refill and note the water level in the frame, and allow the test section to saturate for a minimum of 24 hours.

7) After the 24-hour saturation period, observe and note water level in the upstream manhole.

8) If no drop in water level has occurred during this initial 24-hour period, return after two additional hours and observe and note water level. If no drop in water level has occurred after this two-hour period, the test will be considered successful.

9) If after two hours there has been a drop in the water level, the amount of drop will be noted. Refill the manhole to the initial water level, within 1.5-inches of the top of the cast iron frame. Note the water level.

10) The above sequence of fill and monitor will continue until the water level in the manhole has been maintained at the starting water elevation for two consecutive hours. When the water level remains unchanged (no drop in elevation) for a two-hour period, the test will be considered successful.

11) If after the fourth hour it is determined that the water level cannot be maintained without dropping, the test will be terminated and considered failed.

12) Necessary repairs and/or improvements will be made to the manhole. Repairs shall be made with the knowledge of, and in a manner approved by the Engineer.

13) Upon completion of remedial actions, the manhole shall be retested from the beginning, as indicated above.

14) If during the previous four hours, the water level drop has been at a diminishing rate, the contractor may choose to continue the fill and monitor sequence until the water level has been maintained at the same level for two consecutive hours.

15) Any failed manhole shall be repaired or removed and replaced in a manner approved by the Engineer. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning. The process will continue until each manhole has passed the official test.

G. Deflection Testing of Pipe

1. Not less than 30 days following completion of backfill, the pipe (48-inch and smaller in diameter) shall be tested for deflection with a go/no-go mandrel. Pipe 54-inch and larger in diameter shall be tested for deflection by measuring the inside diameter at 4 points in the cross-section of each section of pipe during the internal visual inspections. The 4 point measurements shall be made using a rig or mandrel that allows measurements vertically and horizontally in the cross-section. Regardless of this time restriction, under no circumstances will the deflection testing be scheduled until all backfill materials have been compacted, and soil density requirements have been met and accepted by the Engineer.

DEFLECTION STANDARDS FOR PIPE				
Pipe Material	Type of Pipe	Testing Standard		Lifetime Standard
		Mandrel and Proving Ring Dimension	Maximum Allowable Deflection	Maximum Deflection
PVC	Flexible	95.0%	5.0%	7.5%
DIP w/ cement lining	Flexible	97.0%	3.0%	3.0%
DIP w/ epoxy lining	Flexible	98.0%	5.0%	5.0%
FRPMP	Flexible	97.25%	2.75%	4.0%

2. The size of each mandrel and proving ring shall be as indicted in the tables below based on type of pipe.

PIPE DIMENSIONS, INCHES PIPE TYPE - SOLID WALL PVC DR 26 STANDARD ASTM D-3034					
Nominal Diameter	OD per Standard	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (95% of Standard ID)	Allowable Deflection (5% of Standard ID)
8	8.400	0.323	7.754	7.521	0.233

PIPE DIMENSIONS, INCHES PIPE TYPE - SOLID WALL PVC DR 25 STANDARD – AWWA C900					
Nominal Diameter	OD per Standard	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (95% of Standard ID)	Allowable Deflection (5% of Standard ID)
8	9.05	0.362	8.28	7.866	0.414
10	11.1	0.444	10.16	9.652	0.508
12	13.2	0.528	12.08	11.476	0.604
14	15.3	0.612	14	13.300	0.700
16	17.4	0.696	15.92	15.124	0.796
18	19.5	0.78	17.85	16.958	0.893
20	21.6	0.864	19.77	18.782	0.989
24	25.8	1.032	23.61	22.430	1.181
30	32	1.28	29.4	27.930	1.470

PIPE DIMENSIONS, INCHES PIPE TYPE - CLOSED PROFILE PVC PR 46 PSI STANDARD - ASTM F1803					
Nominal Diameter	OD per Standard	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (95% of Standard ID)	Allowable Deflection (5% of Standard ID)
30	31.606	1.098	29.41	27.940	1.471
36	38.036	1.3205	35.395	33.625	1.770
42	44.2	1.4125	41.375	39.306	2.069
48	50.57	1.605	47.36	44.992	2.368
54	57.1	1.875	53.35	50.683	2.668
60	63.932	2.296	59.34	56.373	2.967

**Any stiffness rating other than PR 46 will require an updated chart for required sizing from Engineer for approval.

PIPE DIMENSIONS, INCHES PIPE TYPE - SOLID WALL FRPM SN 72** STANDARD - ASTM D3262			
Nominal Diameter	ID per Standard	Mandrel and Proving Ring (97.25% of Standard ID)	Allowable Deflection (2.75% of Standard ID)
30	30	29.175	0.825
36	36	35.01	0.99
42	42	40.845	1.155
48	48	46.68	1.32
54	54	52.515	1.485
60	60	58.35	1.65
66	66	64.185	1.815
72	72	70.02	1.98
78	78	75.855	2.145
84	84	81.69	2.31
90	90	87.525	2.475
96	96	93.36	2.64
102	102	99.195	2.805
108	108	105.03	2.97
114	114	110.865	3.135
120	120	116.7	3.3
132	132	128.37	3.63
144	144	140.04	3.96

**Any stiffness rating other than SN 72 will require an updated chart for required sizing from Engineer for approval.

PIPE DIMENSIONS, INCHES PIPE TYPE – DIP – EPOXY LINED** PC 350 STANDARD - AWWA C 151						
Nominal Diameter	OD per Standard	Epoxy Lining Thickness***	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (95% of Standard ID)	Allowable Deflection (5% of Standard ID)
8	9.05	0.040	0.25	8.47	8.216	0.254
10	11.1	0.040	0.26	10.5	10.185	0.315
12	13.2	0.040	0.28	12.56	12.183	0.377
PIPE DIMENSIONS, INCHES PIPE TYPE – DIP – EPOXY LINED PC 250* STANDARD - AWWA C 151**						
Nominal Diameter	OD per Standard	Epoxy Lining Thickness***	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (97% of Standard ID)	Allowable Deflection (3% of Standard ID)
16	17.4	0.040	0.3	16.72	16.218	0.502
18	19.5	0.040	0.31	18.80	18.236	0.564
20	21.6	0.040	0.33	20.86	20.234	0.626
24	25.8	0.040	0.37	24.98	24.231	0.749
30	32	0.040	0.42	31.08	30.148	0.932
36	38.3	0.040	0.47	37.28	36.162	1.118
42	44.5	0.040	0.52	43.38	42.079	1.301
48	50.8	0.040	0.58	49.56	48.073	1.487
54	57.56	0.040	0.65	56.18	54.495	1.685
60	61.61	0.040	0.68	60.17	58.365	1.805
64	65.67	0.040	0.72	64.15	62.226	1.925

* Pressure Classes other than 250 will require an updated chart for required sizing from Engineer for approval.

** Mandrels used inside epoxy lined pipe shall have plastic skid plates or shall have polyethylene rails.

*** Epoxy lining thickness of 0.040-inch based of 40 mils thickness.

PIPE DIMENSIONS, INCHES PIPE TYPE – DIP – CEMENT LINED PC 350 STANDARD - AWWA C 151						
Nominal Diameter	OD per Standard	Double Cement Lining Thickness	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (97% of Standard ID)	Allowable Deflection (3% of Standard ID)
8	9.05	0.125	0.25	8.30	8.051	0.249
10	11.1	0.125	0.26	10.33	10.020	0.310
12	13.2	0.125	0.28	12.39	12.018	0.372

PIPE DIMENSIONS, INCHES PIPE TYPE - DIP PC 250* STANDARD - AWWA C 151						
Nominal Diameter	OD per Standard	Cement Lining Thickness	Min. Wall Thickness	ID per Standard	Mandrel and Proving Ring (97% of Standard ID)	Allowable Deflection (3% of Standard ID)
16	17.4	0.09375	0.3	16.61	16.114	0.498
18	19.5	0.09375	0.31	18.69	18.130	0.561
20	21.6	0.09375	0.33	20.75	20.130	0.623
24	25.8	0.09375	0.37	24.87	24.126	0.746
30	32	0.125	0.42	30.91	29.983	0.927
36	38.3	0.125	0.47	37.11	35.997	1.113
42	44.5	0.125	0.52	43.21	41.914	1.296
48	50.8	0.125	0.58	49.39	47.908	1.482
54	57.56	0.125	0.65	56.01	54.330	1.680
60	61.61	0.125	0.68	60	58.200	1.800
64	65.67	0.125	0.72	63.98	62.061	1.919

* Pressure Classes other than 250 will require an updated chart for required sizing from Engineer for approval.

3. For all pipe sizes, the mandrel shall be sized based on a percentage of the published Inside Diameter of the type of pipe (material) used, according to the appropriate ASTM and AWWA Standards. Allowances for manufacturing and production tolerances or ovality of pipe shall not be counted as part of the calculation for determining the mandrel and proving ring diameters.

4. The Contractor shall furnish aluminum or steel mandrels for each size and type of pipe used on each project. The mandrels shall meet the diameter requirements

indicated. For testing deflection for each size and type of pipe, and shall not be adjustable. The mandrel shall consist of an unequal number of rails, with a minimum of 9 rails. Rail length shall be at least equal to the nominal pipe diameter. CHARLOTTE WATER will provide the applicable proving rings. Bare steel or aluminum mandrels shall not be pulled through epoxy lined ductile iron pipe. The steel or aluminum mandrel shall be equipped with polyethylene or other plastic skid plates with recessed attachment hardware to prevent damage to the epoxy lining. Shop drawings of mandrels proposed for use in epoxy lined pipe shall be subject to approval by the Engineer. Larger diameter mandrels will require increasing number of rails, and are subject to approval of the Engineer. Maximum spacing between rails shall be 4.0-inches on larger diameter mandrels. Rail length in contact with the pipe wall shall be at least equal to the nominal pipe diameter and not greater than 1.75 times the nominal pipe diameter. Rails shall be the specified diameter for the full rail length. Rails with reduced mid-section diameters shall not be approved.

5. Prior to each use, the Contractor will demonstrate to the Project Inspector that the mandrel tightly fills the proving ring along the full length of the mandrel. The trailing edge of the mandrel shall be the full diameter of the proving ring. The maximum gap between the proving ring and any individual rail shall be less than 1/32-inch. The Contractor shall retain ownership of mandrels at the end of the contract.

6. The mandrel shall be pulled through each section of pipe from manhole to manhole. The mandrel must slide freely through the pipe and service tees with only a nominal hand force applied. No mechanical/pneumatic/hydraulic device shall be used in pulling the mandrel. Any pipe which refuses the mandrel shall be removed and replaced or re-rounded and the bedding shall be properly constructed as specified to prevent excessive deflection. Repairs shall be with the knowledge of and approval of the Engineer. Refusal of the mandrel shall be defined as any location where the mandrel will not freely slide through the pipe. Such sections shall be re-tested for deflection after completion of backfill. Repairs shall be made with the knowledge and approval of the Engineer. Upon completion of remedial actions, the testing procedures shall restart from the beginning.

7. Pipe segments that include aerial crossings that are steel pipe, do not require mandrel testing of the aerial steel pipe. Appropriately sized mandrels may be pulled from each manhole to the beginning point of the steel pipe. Pipe segments that include aerial crossings that are all ductile iron pipe shall be mandrel tested from manhole to manhole with the appropriate sized mandrel.

8. Any section of the pipe not passing the mandrel test shall be uncovered. The pipe shall be checked for damage, and the bedding material replaced and re-compacted, as approved by the Engineer. Re-rounding of the pipe by mechanical means, without uncovering the pipe shall typically not be approved. If re-rounding is approved by the Engineer, any device used for re-rounding shall be subject to approval by the Engineer. The contractor shall schedule all testing and re-testing with the Engineer. All testing procedures shall be verified and witnessed by the Engineer.

3.13 TELEVISION INSPECTION OF SEWER MAINS AND LATERALS

A. The Contractor shall perform closed circuit television (CCTV) inspection of newly installed gravity sanitary sewer and laterals for all newly installed gravity sewer mains and laterals.

B. CCTV Inspections shall not take place until the last 30 days prior to activation or acceptance by CHARLOTTE WATER.

C. CCTV Inspections shall not take place until the last 30 days of the warranty period for the newly installed gravity sanitary sewer and laterals.

D. The television inspection of all new sewer mains and laterals will be performed after all other required testing (low pressure air test, soil density testing, manhole testing, etc.) and inspections have been completed. Under no circumstances will internal inspections be performed until the backfill has been completed and the compaction results have been approved by the Engineer.

E. The Contractor shall use the appropriate equipment to thoroughly clean all debris from each sewer segment. The equipment used for the cleaning operations shall be specifically designed for cleaning sewers. When pipe segments include epoxy lined ductile iron pipe or steel pipe, the cleaning equipment shall be designed specifically for use inside epoxy lined pipe. Equipment submittals must be provided for review and approval. The required equipment shall be high velocity water jet cleaning equipment with various attachments. When pipe segments include epoxy lined pipe, the cleaning pressure and velocity shall be limited as required by the coating manufacturer to prevent damage to the epoxy lining. All solids shall be removed at the downstream manhole of the section being cleaned. Passing material from one sewer segment to another will not be permitted. Cleaning operations shall begin at the most upstream sewers and proceed downstream. The solids shall be removed from the site and properly disposed of at approved locations provided by the Contractor. The cleaning operation is not part of the closed-circuit television inspection procedure. Water for cleaning operations shall be obtained as described in CHARLOTTE WATER's Fire Hydrant Program for Temporary Service.

F. After the sewers are completely cleaned, the sewers shall be inspected via closed circuit television (CCTV). A minimum of 25 gallons of potable water shall be inducted into the uppermost manhole, 1 to 2 hours prior to the CCTV work. The water is intended to assist the Engineer in evaluation of the sewer main. The purposes of the CCTV inspections are to verify that the sewers have been thoroughly cleaned, to document the condition of the new sewers and the locations of service connections, to locate sewer defects prior to acceptance by the Engineer, and to confirm that the new main was properly installed. The camera equipment used for the CCTV inspections shall be self-powered tractor assemblies specifically designed and constructed for such inspection. Lighting for the camera shall be suitable to allow a clear picture for the entire periphery of the pipe. The camera shall be a full color, pan-and-tilt camera. The complete video system (camera, lens, lighting, cables, monitors, and recorders) shall be capable of providing picture quality and definition acceptable the Engineer. The video system shall record directly to a digital computer file format.

G. All inspections shall be performed using I.T.pipes software in the field. I.T.pipes must be installed in the truck that is performing the television inspections and used for the live field inspections. If I.T.pipes with the specific CHARLOTTE WATER template is not in

the truck(s), the work shall immediately cease until it is installed in the truck(s) to be used during the inspection process.

H. The contractor must use the I.T.pipes CHARLOTTE WATER template available from I.T.pipes. This template contains all correct data entry fields, all observation inputs and required parameters, template settings for overlay control and setup, and other settings. The Contractor shall obtain the template prior to performing any CCTV inspections. Inspections performed without using the CHARLOTTE WATER template will be rejected, and the Contractor will have to re-perform the inspections at no cost to the City.

I. WMV recording with embedded meta-data is required. Each submittal to the Engineer shall include the I.T.pipes software database file within the approved structure along with the WMV video files. The Contractor shall make all adjustments necessary to adhere to the required format specified herein including performing the work using the required software at no additional cost to the City. After the first submittal, the Engineer will notify the Contractor of any required changes in the data and file format, and the Contractor shall make such modifications at no additional cost.

J. The digital recording shall include both audio and video information that accurately reproduces the original picture and sound of the video inspection. The video portion of the digital recording shall be free of electrical interference and shall produce a clear and stable image. The audio portion shall be sufficiently free of background and electrical noise as to produce an oral report that is clear and discernible.

K. Video Overlay

1. The video shall include overlay/text display with an initial display screen and with a continuous running screen.

2. Each inspection start shall include overlay display of section details including at a minimum:

    a. City name

    b. Project name

    c. Contractor name

    d. Street name (if applicable)

    e. Date/time of inspection

    f. CLTW MH Start #/MH End #

    g. Pipe material

    h. Pipe size

    i. Direction of video

    j. Weather or Flow Level

    k. Pipe Identifier Number (GM Number)

3. The continuous running screen shall include a constant display of the street name, CLTW MH start #/MH End #, date and distance shall appear on screen.

4. The CCTV inspector shall move or remove overlay display accordingly, so it does not interfere with the inspection review of particular observations/defects as the inspection is occurring.

5. As an observation/defect is noted by the inspector, a text display shall appear with the text describing the observation/defect. Text shall display for 4-5 seconds.

6. Distance shall appear continuously in the lower right corner of the video image as the camera is traveling down the line.

7. It is imperative that distance is accurate. The CCTV inspector shall calibrate/test footage at the beginning of each day as incorrect footage will result in return of inspections.

L. Video Format

1. Completed work shall consist of WMV video files captured live off the inspection camera.

2. Each pipe inspection's observations shall be related to a time point within the video.

3. Each pipe inspection WMV file shall have a related text file, with an identical name but different extension on the file. This file shall contain the distances of each observation and the related time point for that observation.

4. During the inspection, the video file recording shall pause as the operator selects the observation/defect notation, eliminating "on hold" video.

5. The video file resolution shall be 640 x 480 dpi.

6. The audio shall be included within the WMV and not as a separate file.

M. Video Media

1. The database file and the corresponding video files shall be submitted to the Engineer on flash drives or portable external hard drives. One copy of the printed logs (in color) that correspond to the inspections shall be submitted to the Engineer. The Engineer will return the hard drive to the Contractor after the inspections have been reviewed.

2. Each submittal to the Engineer shall include a transmittal letter, listing the file names and all sewer segments and video files included on the hard drive.

N. Customized Data Fields: CHARLOTTE WATER has developed customized data fields for its viewing software. The Contractor will be required to use these data fields, without any modifications, to enter project information for each inspection. These data fields are available for download from CHARLOTTE WATER. Observations for each inspection shall include:

1. Observation distance (part of the CHARLOTTE WATER catalog)

2. Observation defect/description (part of the CHARLOTTE WATER catalog)

3. Counter time observation occurs within digital video (part of the CHARLOTTE WATER catalog)

4. Severity rating for each observation/defect (part of the CHARLOTTE WATER)

5. Infiltration rating (part of the CHARLOTTE WATER catalog)

O. The camera shall be moved through the line in either direction at a uniform rate, but not greater than 30 feet per minute. The camera shall follow closely behind the mandrel. Following distance shall be acceptable to the Engineer and shall allow the Engineer to observe the trailing edge of the mandrel to determine the amount of pipe deflection.

Following distance shall also allow the Engineer to observe other conditions of the pipe, including joints, defects, connections and ponding water. The camera shall be stopped at any defect and service connections and shall be panned, tilted and rotated to fully view the defects and connections. Particular attention should be paid to service connections and changes in pipe materials. All such inspections shall be documented.

P. The inspections shall be completed from manhole to manhole without the need for reverse setups unless approved otherwise by the Engineer. If, during the work, the CCTV inspection is blocked by debris, or a defect which must be repaired, the Contractor shall remove the blockage or repair the defect as authorized by the Engineer. The segment of sewer main will then be cleaned and inspected by CCTV. No additional payment will be made for the initial CCTV inspections that were blocked by debris or required repairs.

Q. The accuracy of the measurements cannot be stressed too strongly. Daily calibration of measuring devices shall be performed. Accurate and continuous footage readings shall be superimposed on the recording for the sections inspected. The date of inspection and manhole designation for each manhole on the section of line inspected shall also be shown.

R. Upon completion of the cleaning and television inspection work, the Contractor shall submit one copy of the final television inspection video and inspection logs to the Engineer. The video and inspection logs shall be clearly labeled as to their contents. The final inspection shall mean that the sewer has been completely cleaned (no debris or defects), and the inspection has been completed from manhole to manhole. If point repairs or main replacements are performed after the inspections are submitted, it shall be the Contractor's responsibility to complete an additional cleaning and CCTV inspection at no additional cost to CHARLOTTE WATER.

S. Prior to cleaning the sewer mains, the sewer laterals shall be cleaned from the cleanout at the property line, or easement line, or road right-of-way line to the connection point at the main. A minimum of 2 gallons of potable water shall be induced into each cleanout prior to the CCTV inspection of the sewer lateral. Sewer laterals shall be inspected by CCTV from the cleanout to the connection point at the main, as specified for mainline sewer mains. The camera equipment used for the CCTV inspections of sewer laterals shall be one specifically designed and constructed for sewer lateral inspections. Lighting for the camera shall be suitable to allow a clear picture for the entire periphery of the pipe. The camera shall be a push type color camera with a minimum of 150 feet of cable. The picture quality and definition shall be to the satisfaction of the Engineer, and the camera does not require pan and tilt capabilities. The video system shall record directly to a digital computer file format, as indicated above. Upon completion of the lateral inspection work, the Contractor shall submit one copy of the final television inspection video and inspection logs to the Engineer. The video and inspection logs shall be clearly labeled as to their contents. The sewer lateral inspection and acceptance will be completed prior to the CCTV inspection of the adjacent sewer main segment.

T. All costs associated with providing the digital television inspections as specified including performing the inspections using I.T.pipes and CHARLOTTE WATER's template shall be included in the various bid items – no separate or additional payment shall be made.

U. All costs associated with cleaning and CCTV inspections on developer projects shall be provided by the developer and at no cost to CHARLOTTE WATER.

3.14 REPAIRS

A. All repairs of any type shall be with the prior knowledge and approval of the Engineer. All repair methods shall be subject to review and approval of the Engineer. 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 pipe material. All leaks shall be repaired by identifying and exposing the defective section of pipe and completing repairs as follows:

1. FRPM or Ductile Iron Pipe: Defective or damaged pipe including leaking joints shall be removed and replaced with sound new pipe. The pipe shall be re-connected with approved couplings as specified in this document. Repairs shall be limited to one every one hundred feet not to exceed three pipe repairs between manholes. Deficiencies in excess of these limitations shall be corrected by relaying the section of pipe manhole to manhole.

   Poly Vinyl Chloride Pipe (PVC): Defective or damaged pipe including leaking joints shall be removed and replaced with sound new pipe. The pipe shall be re-connected with approved couplings as specified in this document. Pipe that is sound and otherwise acceptable, but will not pass the deflection test, will be exposed and the bedding materials removed and replaced. Repairs shall be limited to one every one hundred feet not to exceed three pipe repairs between manholes. Deficiencies in excess of these limitations shall be corrected by relaying the section of pipe manhole to manhole.

   Re-rounding of the pipe by mechanical means, without uncovering the pipe shall typically not be approved. If re-rounding is approved by the Engineer, any device used for re-rounding shall be subject to approval by the Engineer. Re-rounding will not be permitted within 4 feet of a pipe joint. Over-deflection of the pipe near the joint will be corrected by excavation only.

2. PCCP: Defective or damaged pipe including leaking joints shall be removed and replaced with sound new pipe. Pipe re-connections shall be made, and joint leaks repaired, using reinforced concrete collars or repair sleeves pre-approved by the Engineer.

   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.

   Repairs shall be limited to one every one hundred feet not to exceed three pipe repairs between manholes. Deficiencies in excess of these limitations shall be corrected by relaying the section of pipe manhole to manhole.

3. Aerial Steel Pipe: Defective or damaged pipe including leaking joints shall be removed and replaced with sound new pipe.

4. Laterals: Defective or damaged laterals including leaking joints, cracked pipe or fittings, shall be removed and replaced with sound new pipe. Pipe re-connections shall be made, and joint leaks repaired, using repair couplings pre-approved by the Engineer.

   Repairs shall not to exceed two pipe repairs between the main and the cleanout. Deficiencies in excess of these limitations shall be corrected by relaying the lateral from the main to the cleanout.

5. Manholes: Any damage to the interior wall of the manhole resulting from penetration of the lift holes shall be repaired with non-shrink cement grout. Defective or damaged manhole sections or joints shall be removed and replaced with sound new manhole sections. Leaks through manhole joints or walls or around pipe collars, may be repaired from inside the manhole with non-shrink cement grout. If the size of the leak, or the external water pressure, prevents such repairs, the manhole shall be excavated and repaired from outside. Leaks around boots or gaskets used to join pipe to manholes shall be repaired by external concrete collars, removed and replaced with, sound new manhole connectors, or as approved by the Engineer.

6. Manhole Liner: Any damage to the manhole liner shall be repaired per specifications in Chapter 16.3 Manhole Rehabilitation as well as the liner Manufacturer's instructions, standards and/or recommendations.

7. Wet wells: Any damage to the interior wall of the precast wet well resulting from penetration of the lift holes shall be repaired with non-shrink expansion cement grout. Defective or damaged precast wet well sections or joints shall be removed and replaced with sound new precast sections.

   Leaks through wet well joints or walls or around pipe collars, shall be removed and replaced with sound new precast sections, due to the critical nature of the wet well application. Repairs to prevent leaking shall not be approved.

   Leaks around boots or gaskets used to join the pipe to the precast wet well shall be removed and replaced with sound new manhole connectors. Repairs to prevent leaking shall not be approved.

8. Tracer Wire: Any damage to the tracer wire shall be repaired by removing and replacing the damaged wire and splicing the new wire per the Wire Splice System per the Standard Details and as specified in Part 2 and 3 of this Specification describing splicing and/or joining sections of tracer wire.

3.15 FINAL INSPECTION

A. A final inspection will be held for each project once construction and complete restoration has been completed. The Contractor SHALL ATTEND the final inspection. During the final inspection, all structures shall be opened and inspected. All other features of the project, either constructed or reconstructed, shall also be inspected. The official tracer wire test shall be conducted during the Final Inspection process, unless otherwise approved by the Engineer. The Contractor shall be responsible for providing equipment and labor, as may be necessary, to conduct the final inspection and to provide a safe worksite. Deficiencies, if any, shall be noted for correction by the Contractor. The Contractor will schedule the work with the Inspector. Any and all corrective actions necessary to correct a deficiency noted at the final inspection shall be completed prior to final acceptance of the work and project.

3.16 WARRANTY PERIOD

A. A one-year warranty period is required. The project warranty period will be established from the date all deficiencies (if any) have been corrected, following the final inspection, and will extend for one year, unless extended as indicated below.

B. Should deficiencies develop during the warranty period, the Engineer shall determine the severity of the deficiency and advise the Contractor of its priority rating. The priority ratings shall be defined as Emergency, Major, Minor, or Routine. The Engineer reserves

the sole right to determine the priority rating of a deficiency and to raise or lower the rating as needed. The Contractor shall respond to these deficiencies according to the following schedule:

1. Emergency: Once notified, the Contractor shall report to the project site within a maximum of 2 hours and shall mobilize and take all actions necessary to make the site safe. The Contractor and the Engineer will agree on a course of required actions and timeline for completing those actions. All work necessary to correct the Emergency deficiency shall be completed as quickly as possible.

2. Major: Once notified, the Contractor shall mobilize to the project site within a maximum of 2 business days. The Contractor will schedule the work with the Inspector. All work necessary to correct the Major deficiency shall be completed within a maximum of 5 business days of mobilization, or according to timeline approved by the Engineer.

3. Minor: Once notified, the Contractor shall mobilize to the project site within a maximum of 10 business days. The Contractor will schedule the work with the Inspector. All work necessary to correct the Minor deficiency shall be completed within a maximum of 5 business days of mobilization, or according to timeline approved by the Engineer.

4. Routine: Once notified, the Contractor shall mobilize to the project site within a maximum of 25 business days. The Contractor will schedule the work with the Inspector. All work necessary to correct the Routine deficiency shall be completed within a maximum of 5 business days of mobilization, or according to timeline approved by the Engineer.

C. A warranty inspection will be scheduled for the project during the final month of the project warranty period. The Contractor SHALL ATTEND the warranty inspection. During the warranty inspection, all structures shall be opened and inspected. All other features of the project, either constructed or reconstructed, shall also be inspected. The Contractor shall be responsible for providing equipment and labor, as may be necessary, to conduct the warranty inspection and to provide a safe worksite. Any deficiencies, if any, shall be noted for correction by the Contractor. The Contractor will schedule the work with the Inspector. The Engineer reserves the sole right to determine the priority rating of each deficiency noted at the warranty inspection. Any and all corrective actions necessary to correct a deficiency noted at the warranty inspection shall be completed within a maximum of 30 days following the warranty inspection.

D. Deficiencies noted and corrected during the warranty period will extend the project warranty period. The contractor shall warrant and guarantee the corrected work for one year from the date the deficiency is corrected. A warranty inspection will be conducted within the final month of the extended warranty period. The extended warranty inspection will be conducted as described above for a warranty inspection for the specific items that required warranty repairs during the warranty period.

END OF SECTION