

SECTION 4.0

DESIGN CONSIDERATIONS FOR WASTEWATER SYSTEM EXTENSIONS

4.1 GENERAL

The purpose of this section is to provide the Developer or Engineer with a guideline to assist in the development of plans and specifications for sewer system extensions which will meet the requirements and objectives of the Commission. As a minimum, the Contract Documents for any proposed extension must address satisfactorily the topics contained herein.

4.1.1 Private Sewers

Private sewer collection systems shall be designed and constructed in accordance with the standards and requirements of the NCDWQ. In addition, all private sewer mains which connect to the Commission's system shall be tested in accordance with the requirements of Section 4.5 of this Manual.

4.2 LOCATION AND ALIGNMENT

4.2.1 Depth of Cover

4.2.1.1 Sanitary sewers shall have a minimum cover of three feet (3') as measured from the top (crown) of the pipe to the finished grade. Where this requirement is impossible to meet, special precautions such as the use of ductile iron pipe shall be taken to insure protection of the sewer from physical damage. The Commission shall determine the acceptability of such installations.

4.2.1.2 Wherever feasible, gravity sewer shall be installed at such depths as required to allow all discharges to the sewer system to occur without the use of pump stations.

4.2.2 Relationship of Mains to Property Lines and Rights-of-Way

All sanitary sewers shall be located within dedicated rights-of-way or permanent sewer easements such that the Commission has unrestricted access to the line and all appurtenances thereof.

4.2.2.1 Approval of sanitary sewer extension plans shall be contingent upon procurement of the easements and encroachment agreements necessary to meet this requirement. See Section 5.7 for the requirements for submission of easement documents.

4.2.2.2 Sanitary sewers shall be centered in a permanent easement of adequate width to allow excavation and maintenance of the line. In no case shall the permanent easement for sewers be narrower than that given by the following table:

	DEPTH OF COVER (feet)	MIN. EASEMENT (feet)
FORCE MAIN	ALL	10
GRAVITY SEWERS	0 - 6	20
	>6 -15	30
	Greater than 15	40

4.2.2.3 Wider permanent easements may be required by the Commission where, in the opinion of the Department Engineer, conditions warrant. Such easement shall be centered on the main.

4.2.3 Relationship of Sanitary Sewers to Water Mains and Wells

4.2.3.1 See Section 3.2.3 of the Manual for sewer and water main minimum vertical and horizontal separation distances.

4.2.3.2 All sewers shall be located a minimum of one hundred feet (100') away from any well. In those cases where a sewer is located within one hundred feet (100') of a well, ductile iron pipe with mechanical joints shall be specified. In no case shall a sewer be located within fifty feet (50') of a well.

4.2.4 Relationship of Sanitary Sewers to Structures and Pipes

4.2.4.1 Sanitary sewers shall not be installed within twenty feet (20') of any part of permanent buildings or other structures.

4.2.4.2 Except by special consent of the Commission, the lateral separation between gravity sewer, storm sewers and force mains shall not be less than ten feet (10').

4.2.4.3 When underground structures or storm sewers are encountered, twelve inches (12") vertical separation shall be maintained. Where the minimum separation cannot be maintained, the location and the corrective action specified shall be shown on the plans so that the Commission may determine the acceptability of the planned corrective measures.

4.2.4.4 When a sanitary sewer must be installed under a storm sewer and twenty-four inches (24") of vertical separation cannot be obtained, ductile iron pipe shall be specified. When vertical separation is less than twelve inches (12"), supports shall be provided for the storm sewer in accordance with the Standard Details.

4.2.5 Relationship of Sanitary Sewers to Impoundments and Creeks

4.2.5.1 Sanitary sewers shall not be installed under any part of Impoundments.

4.2.5.2 Sanitary sewers (including manholes) shall be located such that their centerlines are a minimum of forty feet (40') from the top of the nearest bank of adjacent streams, creeks, ditches, etc. This distance shall be increased by the Commission as it deems appropriate if the bank shows evidence of instability. If documentation satisfactory to the Commission is provided which demonstrates that the sanitary sewer can be more closely located to a particular drainageway without detrimental consequences, the Commission may agree to permit this.

4.2.5.3 Whenever practical sanitary sewers shall be protected from inflow of stormwater runoff by locating manholes in areas which are not subject to flooding. When manholes must be constructed in areas subject to flooding, the elevation of the manhole top shall be two feet (2') above the elevation of the one hundred (100) year flood elevation or the manhole ring and cover shall be watertight and vents shall be provided at intervals no greater than 1000 feet. The vents shall extend a minimum of two feet (2') above the elevation of the one hundred (100) year flood. Manholes which are subject to being pressurized by surcharging or which are likely to be vandalized shall have mechanically restrained covers. Manholes having restrained, watertight covers which are subject to pressurization by surcharging shall be designed to withstand the maximum potential surcharge without damage. For design purposes, the maximum potential surcharge shall be that surcharge which would result from a prolonged outage of the nearest downstream pump station.

4.2.6 Manhole Location and Grade

4.2.6.1 The maximum distance between manholes measured horizontally along the centerline of the gravity sewer shall be 425 feet.

4.2.6.2 Manholes shall be provided at all horizontal and vertical changes in alignment of a gravity sanitary sewer.

4.2.6.3 Any changes in the nominal pipe diameter of a gravity sewer must be accomplished by installation of a manhole.

- 4.2.6.4 Manholes installed in pavement shall have their cover set flush with finished grade and be located outside of designated parking spaces. Whenever practical, manholes located in streets shall be located in the center of the street.
- 4.2.6.5 The minimum elevation difference between the "invert in" and the "invert out" of manholes shall be 0.1' . Exceptions are 1) when there is a change in flow direction of greater than 90 degrees the minimum difference shall be 0.2', and 2) when pipes of different sizes converge in a manhole, the inside tops of the pipes shall be at the same elevation.
- 4.2.6.6 The elevation difference between the "invert in" and invert out" of manholes shall be either (1) < 0.5' or (2) > 2.5'. Manholes having pipes entering at elevations > 2.5' above the outlet shall be drop manholes. Manholes shall not be designed utilizing a difference in invert elevations between 0.5' and 2.5' except as follows. A difference in the "invert in" and the "invert out" elevations of up to 1.0' will be allowed in instances where there is sufficient justification, the incoming sewer is installed at a grade which exceeds the minimum by at least 50% and a smooth flow path is constructed between the influent and effluent piping.
- 4.2.6.7 Where a natural slope will permit the use of a sewer grade in excess of the NCDWQ minimum slope, the Engineer shall (where feasible) use the available grade to increase the slope of the gravity sewer rather than designing for the minimum slope with large invert drops. The use of invert drops greater than 0.5' shall be unacceptable (except as provided in paragraph 4.2.6.6) where the line may be steepened to absorb all or a portion of the excess grade without exceeding the maximum slope allowable by the NCDWQ.
- 4.2.6.8 Invert drops shall be accomplished by providing an invert channel of constant slope which meets the elevations of the influent and effluent pipes.

4.2.7 Location of Sewer Services

- 4.2.7.1 Plans for projects which propose the creation of lots shall include the provision of individual sewer services to each lot including any residual parcels and areas reserved for future lots. The size and location of services shall be based upon the anticipated use of the lot and require the Commission's approval.
- 4.2.7.2 Services shall be installed at right angles to the gravity sewer. The maximum cleanout spacing as measured along the service line centerline shall be seventy-five feet (75') for four-inch (4") and six-inch (6") services.

- 4.2.7.3 The service cleanout shall be placed at the right-of-way limit, or edge of the easement, five feet (5') downstream (with respect to sewer flow) of the water meter unless otherwise directed by the Commission..
- 4.2.7.4 When project design dictates that electric cables are to be placed on the same side of the roadway with the sidewalk, the cleanout for that side shall be placed 6' behind the edge of the sidewalk.
- 4.2.7.5 Cleanouts located in non-traffic, unpaved areas shall be constructed of PVC. Cleanouts located in traffic or paved areas shall be installed with a sewer cleanout box set to finished grade as shown in the Standard Details.
- 4.2.7.6 Inverts of services discharging into manholes shall be shown on the plans.
- 4.2.7.7 Sewer services that include discharges from car washes and similar facilities shall include an oil and sand separator in accordance with the plumbing code.
- 4.2.7.8 Grease interceptors shall be required for food service facilities in accordance with the Standard Details.

4.2.8 Location of Force Main Appurtenances

- 4.2.8.1 Manual air release valves as specified in Section 8.5.4 of this Manual shall be located at all peaks of wastewater force mains except where in the opinion of the Commission an automatic air release valve is necessary. A peak shall be defined as the point of maximum elevation of the force main invert which slopes upward toward the hydraulic grade line.

If possible, force mains should be designed without high points and with the top of the force main below the hydraulic grade line at the minimum pumping rate so that air release valves will not be needed. If elimination of high points is not feasible, a manual air-release valve should be installed at each significant high point where air could become trapped. A high point may be considered significant if it is two feet or more above the minimum hydraulic grade line or when pumping is intermittent above the static head line.

- 4.2.8.2 The maximum interval between air release valves should not exceed 1,500 feet as measured horizontally along the pipe centerline.

4.2.8.3 Where the invert elevation of a force main exceeds the hydraulic grade line, the Engineer shall ensure that the force main pipe is of sufficient strength to withstand the internal vacuum which will exist in the line during maximum service discharge. Upon request, the Engineer shall supply the Commission with documentation demonstrating that the deflection of the pipe due to vacuum will not cause leakage.

4.2.8.4 Air release valves for wastewater force mains shall be installed in standard manholes as shown in the Standard Details.

4.3 SIZING AND DESIGN OF SANITARY SEWERS AND APPURTENANCES

4.3.1 Sizing of Gravity Sewers

4.3.1.1 The minimum gravity main size shall be 8 inches nominal inside diameter. Unless otherwise directed or permitted by the Commission, all gravity sewers shall be designed and sized to serve the entire natural drainage basin area which is adjacent to the route of the proposed main, i.e. the gravity main shall be of sufficient size and placed on an adequate grade to allow extension to the natural basin ridge line.

4.3.1.2 Sanitary sewer design capacity for extensions serving dwelling units shall be based upon a wastewater discharge of 120 gallons per day per bedroom. The minimum design discharge per dwelling unit shall be 240 gallons per day. When the occupancy of a dwelling unit exceeds two (2) persons per bedroom, the volume of sewage shall be determined by the maximum occupancy at a rate of sixty (60) gallons per person per day. Selection of design capacity for sanitary sewers shall be in accordance with the latest NCDWQ guidelines.

4.3.1.3 Sanitary sewer design for non-residential developments shall be in accordance with the latest NCDWQ guidelines and shall be subject to the approval of the Commission.

4.3.1.4 The following table (Table 4-1) shall be used to obtain design flows for areas without existing development. Table 4-1 is intended only as a minimum design standard for the classification listed. The Engineer shall be responsible for insuring that the design discharges utilized in sizing sewer collection facilities are adequate for the area which the extension is to serve.

TABLE 4-1
AVERAGE DESIGN SEWER DISCHARGES FOR
UNDEVELOPED RESIDENTIAL, COMMERCIAL
AND INDUSTRIAL AREAS

<u>Residential at 80 qpcd</u>	<u>GPD/Ac.</u>
High Density - 12 persons/acre	960
Medium Density - 10 persons/acre	800
Low Density - 7 persons/acre	560
Commercial	880
Industrial (within and adjacent to existing Industrial Park)	1600
Other Industrial Areas	500

- 4.3.1.5 Gravity sewers shall be sized to carry average design discharge at one-half full flow. Gravity sewers shall also be evaluated as to their ability to carry the peak design (average design discharge X 2.5) at full flow.
- 4.3.1.6 The slopes of sanitary sewers shall, whenever feasible, exceed the NCDWQ minimum requirements by a factor of 1.5. The NCDWQ minimum slopes for sanitary sewers shall be used only when necessary to serve the required area without the use of a pump station or when other factors make steeper slopes impossible or infeasible. The Engineer shall in all cases strive to use the steepest available slope in the upper reaches of collection systems where further extension is not possible due to topography or other circumstances.
- 4.3.1.7 Gravity sewers shall be designed to provide mean velocities, when flowing full, of not less than 2.0 feet per second, based on Manning's formula using an "n" factor of 0.013 provided however; that the minimum slopes which shall be used are as set forth in Table 4-2.

TABLE 4-2

**NCDWQ MINIMUM AND MAXIMUM DESIGN SLOPES
FOR GRAVITY AND SANITARY SEWERS**

Pipe Diameter (inches)	Minimum Slope	Maximum Slope	Pipe Diameter (inches)	Minimum Slope	Maximum Slope
4	1.0%	NA	16	0.14%	3.3%
6	0.60%	NA	18	0.12%	2.8%
8	0.40%	8.2%	21	0.10%	2.3%
10	0.28%	6.1%	24	0.080%	1.9%
12	0.22%	4.8%	27	0.067%	1.6%
14	0.17%	3.9%	30	0.058%	1.4%
15	0.15%	3.5%	36	0.046%	1.1%

4.3.1.8 Construction Tolerances/Acceptance of Sewer Lines

The Commission recognizes that a good portion of projects designed in its service area are in flatlands with little or no natural fall to allow design at greater than NCDWQ minimums.

Therefore, acceptable grade tolerances after installation have been established based on the Manning formula utilizing an “n” factor of 0.013 and a required flow velocity of 2 feet per second and are shown on Table 4-3.

Table 4-3 establishes grades as follows:

- 1) A minimum grade that is acceptable without removing the installation or paying GUC a maintenance fee.
- 2) A minimum grade that is acceptable without removing the installation but requiring payment of a maintenance fee.
- 3) A maximum above the design grade which is acceptable without payment of a maintenance fee. Installations on grades steeper than the maximum above the design grade will require payment of a maintenance fee for loss of usable grade.

Maintenance fee calculations are based on the number of miles of collector lines on our system and the cost of maintenance of these lines on a per foot basis.

**TABLE 4-3
GUC ACCEPTABLE GRADES AFTER INSTALLATION**

(1) Line Size	(2) % Design Grade	(3) % Minimum Grade w/out Maint. Charge	(4) % Minimum Grade w/Maint. Charge	(5) % Grade Above Design Grade w/no Maint. Charge
8"	0.40	0.36	0.33	0.42
10"	0.28	0.27	0.25	0.29
12"	0.22	0.21	0.19	0.23
14"	0.17	0.16	N/A	0.18
15"	0.15	0.14	N/A	0.16

Notes for Table 4-3

- 1) 8" - 12" lines installed flatter than minimum grade shown in Column 4 must be replaced.
- 2) 14" and 15" lines installed flatter than minimum grade shown in Column 3 must be replaced.
- 3) Column 5 will apply in areas where future line extensions are feasible and usable grade has been lost due to increased slope.

4.3.1.9 Construction Tolerances/Manholes

The as-constructed pipe inverts at manholes shall be within 0.05 feet (plus or minus) of the elevations shown on the plans. In the determination of compliance of a sanitary sewer project with established tolerances the more restrictive of paragraph 4.3.1.8 and 4.3.1.9 shall apply.

4.3.2 Sizing of Wastewater Force Mains

4.3.2.1 The minimum force main size shall be four inches. Force mains shall be sized such that the average velocity of flow for the pump design discharge is not less than 2.0 feet per second.

4.3.2.2 Unless otherwise permitted by the Commission, the friction losses due to the force main shall be calculated using the Hazen-Williams formula with a friction factor (C) of 120.

4.3.3 Sizing of Wastewater Pumps and Wet Wells

4.3.3.1 Pumps specified for installation in duplex pump stations shall be sized such that each pump is capable of individually pumping the peak discharge (2.5 x average design inflow) as calculated for the gravity sewer collection system(s) contributing to the system.

Where existing sewers will discharge to the proposed pump station, the design discharge attributable to the existing sewers shall be calculated using the same criteria for new gravity sewers as given in Section 4.3.1.

4.3.3.2 Wet wells shall be sized such that 2-8 pump-on/pump-off cycles (pump starts) occur during each hour at average design sewage inflow.

4.3.4 Gravity Flows Versus Pump Stations

4.3.4.1 Because pump stations are: (1) inherently less reliable, (2) more expensive to operate and, (3) more likely to cause environmental problems than gravity sewers, they shall be incorporated into the design of a project only as a last resort. Projects utilizing pump stations or creating a future need for pump stations will not be approved unless documentation satisfactory to the Commission is submitted justifying the installation of a pump station in lieu of a gravity sewer. In situations where no reasonable alternative exists the Commission may approve the installation of a pump station, provided the area served by gravity sewers has been maximized. In situations where a gravity sewer is not available, the Commission may approve the installation of a privately owned and maintained pump station and force main.

4.3.4.2 The documentation submitted for pump stations must include the following:

4.3.4.2.1 An analysis demonstrating that the receiving sewers have adequate capacity to carry the projected discharge in accordance with Section 4.3.1. The analysis must also include the identification of any uncommitted capacity remaining.

4.3.4.2.2 A cost/benefit analysis which includes initial costs and projected operation and maintenance costs which clearly indicates that a pump station is less expensive than a gravity collection system.

4.3.4.3 The Commission may agree to accept ownership and maintenance of pump stations designed and constructed to the standards set forth in this Manual subject to the following conditions:

- 4.3.4.3.1 The necessary documentation described in Section 4.3.4.2 must be provided to the Commission.
- 4.3.4.3.2 The Commission determines that acceptance of ownership is in its best interest.
- 4.3.4.3.3 Easement, satisfactory to the Commission, is provided for unrestricted access to and operation and maintenance of the pump station.

4.4 INSTALLATION OF SANITARY SEWERS AND APPURTENANCES

4.4.1 General

The Contract Documents for sewer system extensions shall as a minimum direct attention to the following requirements in such a way that insures installation satisfactory to the Commission. Construction safety shall be addressed in a manner consistent with requirements for water system extensions contained in Section 3.4.2.

4.4.2 Replacement of Damaged Facilities and Structures

The Contract Documents for sewer extension projects shall insure that all structures, pavements, utilities, and other facilities which may possibly be damaged as a result of project work are replaced or repaired in a manner which meets the approval of the owner of such structures or facilities or any governing bodies having jurisdiction.

4.4.3 Connection of New Sewers to Existing Facilities

- 4.4.3.1 No connection to, or alteration of any existing facilities owned or maintained by the Commission shall be permitted without the express permission of the Commission and, where required, the presence of the Commission's Representative except as directed by the Commission.
- 4.4.3.2 Where a connection or alteration of any existing facilities is approved, the connection or alteration shall conform to the standards of the Manual for new installations.
- 4.4.3.3 Connections of new sewers to existing manholes shall be accomplished by machine coring and the installation of a flexible connector meeting the requirements of Section 8.4.5 of the Manual.

4.4.4 Salvage of Commission Owned Facilities

When project work results in removal of Commission owned facilities or equipment, the Contractor shall be required to deliver those facilities or equipment undamaged to the Commission's Operation Center, if requested to do so by the Commission.

4.4.5 Sewer Construction and Excavation

- 4.4.5.1 Pipe installation shall be performed only in the presence of the Commission's Representative, except as authorized by the Commission.
- 4.4.5.2 The Contract Documents shall specifically address excavation, pipe Foundation and Bedding, pipe installation, and Haunching requirements. Satisfactory construction materials shall be identified and either construction methods or performance standards shall be specified. If standard references are cited in lieu of specific requirements, the Engineer shall furnish the Commission, at no cost, two (2) copies of the cited references, if requested to do so.
- 4.4.5.3 No deviation from line and grade shown on the Approved Plans shall be permitted by the Contract Documents without the approval of the Commission. Any proposed deviation will require submission of revised Contract Documents to the Commission for review and approval.
- 4.4.5.4 Pipe cutting, where permitted, shall be done in accordance with the written recommendations of the pipe manufacturer. Only factory cut ends shall be used for solvent weld joints.
- 4.4.5.5 The Contract Documents shall require the Contractor to prevent surface water from accumulating in the trenches. Trenches shall be free of water during pipe installation.
- 4.4.5.6 The Contract Documents shall provide for the construction of a Foundation of No. 57 crushed stone in the bottom of trenches when unstable material is encountered. Such unstable material shall be removed to the depth required by the Commission and replaced with No. 57 crushed stone such that the pipe will be adequately supported throughout the entire length. Excavation below the planned pipe invert elevation as shown on the Approved Plans shall be refilled with No. 57 crushed stone. This stabilization stone shall be in addition to the required 4" of No. 57 crushed stone bedding.

- 4.4.5.7 The Contract Documents shall ensure that trenches for wastewater force mains are excavated to provide vertical and horizontal curves which will not exceed the permissible longitudinal deflection of the pipe. Longitudinal deflections for wastewater force main pipe shall be addressed in the Contract Documents in a manner which is in accordance with the requirements for water main deflection specifications. The Engineer shall refer to Section 3.4.6.5 for these requirements.
- 4.4.5.8 The Contract Documents shall require thrust blocking at each horizontal and vertical change in direction of wastewater force mains. Trenches shall be excavated to provide uniform support of the blocking on undisturbed soil. The concrete shall be placed as shown in the Standard Details and shall not interfere with the removal of any bolts, fasteners, or fittings.
- 4.4.5.8.1 In lieu of concrete thrust blocking, restrained piping systems may be used in a manner which is in accordance with the requirements for water mains as specified in Section 3.4.6.9.1 of this Manual.
- 4.4.5.9 The Contract Documents shall require trenches for gravity sewer to be excavated in straight lines and uniformly sloped between manholes or junction structures. Trenches for sanitary sewer pipe, except ductile iron pipe, shall be excavated a minimum of four inches (4") below the pipe bottom in order to receive the required Bedding of No. 57 crushed stone. Ductile iron pipe may be laid on stable undisturbed earth, or suitable loose soil compacted to a minimum of 95% Standard Proctor Density by AASHTO-T99 in lieu of No. 57 crushed stone.
- 4.4.5.10 The Contract Documents shall require excavation for manholes and wet wells to extend a minimum of twelve inches (12") below the bottom of the structure and backfilling to the proper elevation with No. 57 crushed stone and compacted. Prior to placement of any stone, the subgrade shall be dewatered and inspected by the Commission. The subgrade shall be of undisturbed earth; the surface shall be free from mud, muck and organics; and shall be sufficiently stable to remain firm and intact under the feet of the workmen. If, in the opinion of the Commission, the subgrade is unsuitable, soil bearing pressure testing may be required to verify the adequacy of the subgrade to support the maximum operating bearing pressure of the installed structure plus a 2.0 factor of safety. Testing, if required, shall be performed by a qualified geotechnical engineering firm.

The unsuitable material shall be excavated to the depth required by the Commission's Representative and backfilled with No. 57 crushed stone.

4.4.5.11 The specifications shall include the requirement that NC One Call shall be contacted prior to any excavation and shall also note that locations of existing utilities by NC One Call are good only for ten (10) days after the date of location.

4.4.5.12 The Contract Documents shall advise the Contractor that pavement cuts within the City of Greenville require a permit from the City of Greenville Public Works Department.

4.4.6 Backfilling

4.4.6.1 Backfilling shall be performed only with the approval of the Commission.

4.4.6.2 Terms used to indicate backfill zones in this section are capitalized and are defined in Section 1.3.1.2 of the Manual.

4.4.6.3 Special care shall be taken in writing the Contract Documents so that backfilling for sewers and related structures will be done in a manner which will provide satisfactory support and restraint of all pipes, fittings, equipment, and structures. As a minimum, Bedding, Haunching, and Initial Backfill for sewers, manholes, junction boxes, wet wells, etc. shall be compacted to 95% Standard Proctor (AASHTO-T99).

4.4.6.4 Backfill material shall be free of debris, organic materials, large stones, large clods, frozen conglomerates, or other material which might in any way damage the pipe or preclude proper compaction of the backfill. The Commission reserves the right to reject material which, in its opinion, is unsuitable. Acceptable soil materials are ASTM 2487 soil types SW, SP, SM and SC.

4.4.6.5 The Contract Documents shall require the Bedding, Haunching and Initial Backfill of ABS & PVC composite, solid wall PVC and vitrified clay pipe to be No. 57 crushed stone compacted to 95% Standard Proctor Density (AASHTO T-99) as shown in the Standard Details.

4.4.6.6 The backfill for manholes, wet wells, and structures shall be brought to planned elevation in even lifts on all sides of the structures. Compaction shall be as specified for the adjacent pipe.

4.4.6.7 The Final Backfill shall be provided using materials and methods suitable to provide the compaction necessary to prevent settlement which would adversely affect existing or proposed land use. In all cases compaction shall be no less than 90% Standard Proctor (AASHTO-T99).

Backfilling within the right-of-way of the NCDOT, the City of Greenville, railroads, and other right-of-way owners shall be subject to the owner's requirements.

4.4.6.8 All force mains shall be installed with three inch (3") wide metallic detectable tape. The tape shall be clearly marked "Sewer" and shall be centered over the main twelve inches (12") below finished grade. Any breaks in the tape shall be repaired in accordance with the manufacturer's recommendations.

4.4.6.9 The Contract Documents shall require the disturbed ground surface to be graded to prevent ponding of water and seeded and mulched upon completion of backfilling operations. Seeding and mulching shall be in accordance with the requirements and recommendations of the Land Quality Section of the Division of Land Resources.

4.4.7 Installation of Manholes and Wet Wells

4.4.7.1 Foundations for manholes and wet wells shall be in accordance with Section 4.4.5.10.

4.4.7.2 Ensure that crushed aggregate bedding for manholes and wet wells is properly installed and is true to line and grade. Set structure base on bedding and verify conformance with line and grade as shown on the plans and that the structure is set plumb.

4.4.7.3 Manholes deeper than twelve feet (12') as measured from the top of the manhole ring and cover to the lowest manhole invert or from the finished ground surface elevation at the manhole to the lowest manhole invert, whichever is greater, shall be provided with an extended base. Inverts and benches shall be built in accordance with the Standard Details.

4.4.7.4 The manhole inverts shall be constructed with a width and height equal to that of the effluent pipe and shall be so brushed and trowelled that a minimum energy loss occurs in the manhole due to invert roughness.

4.4.7.5 Placement of concrete shall be limited to those days when the temperature is 34 degrees and rising, unless approval to the contrary is given by the Commission.

4.4.7.6 Manholes less than four feet (4') in depth shall be given special design considerations. Proper access to the sanitary sewer for inspection and cleaning must be provided. Flat top manholes shall be used only with written approval from the Commission and shall require submission of shop drawings in accordance with Section 5.5 of the Manual.

4.4.8 Installation of Services

- 4.4.8.1 Services shall be provided to each lot as required by Section 4.2.7 of this Manual and as shown in the Standard Details.
- 4.4.8.2 The minimum service size is four inches (4"). The size of services shall be subject to the approval of the Commission. Minimum slopes for services shall be in accordance with NCDWQ requirements as given in Section 4.3.1.7 of this Manual.
- 4.4.8.3 Each service shall be provided with a cleanout located as described in Section 4.2.7.
- 4.4.8.4 The Contract Documents shall ensure that excavation for services will conform with the requirements for mains given in Section 4.4.5.9 of this Manual. Bedding with No. 57 crushed stone is required for services in accordance with the Standard Details.
- 4.4.8.5 Whenever practical, services shall discharge directly into manholes. Services to existing or proposed manholes shall be installed with a rubber connection sleeve as required by Section 8.4.5 of the Manual.
- 4.4.8.6 Where services are installed by dry boring, the service shall be installed within steel encasement pipe meeting the requirements of Section 8.3 of the Manual. The encasement pipe shall extend a minimum of five feet (5') from the edge of the pavement on either side, unless approval to the contrary is given by the Commission.
- 4.4.8.7 Sewer services larger than six inches (6") shall be provided with manholes in lieu of cleanouts and shall be connected to the main by use of a standard manhole.

4.4.9 Installation of Air Release Valves for Force Mains

4.4.9.1 Where air release valves are required by the Commission or Section 4.2.8 of this Manual, the valves shall be installed in standard manholes.

4.4.9.2 Manual air release valves shall be provided by tapping the main and installing a standard water service clamp, a corporation stop, one-inch (1") service tubing, and a Mueller P-14258 lock wing angle meter stop in accordance with the Standard Details. The one-inch (1") tubing shall have a minimum cover of twenty-four inches (24").

4.4.10 Pump Installation and Site Work

4.4.10.1 The wet wells and valve vaults for pump stations shall be set plumb at the locations indicated on the Approved Plans. The wet well shall be no closer than twenty feet (20') plus the wet well depth to the pump station site easement, or property line.

4.4.10.2 The backfill around structures such as wet wells and valve vaults shall be placed in even lifts on all sides of the structure and compacted to 95% Standard Proctor Density as determined by AASHTO-T99.

4.4.10.3 The Contract Documents shall ensure that the pump station site area is graded smoothly with no depressions which would permit ponding of water. The slopes shall be such that the site is stable and non-eroding. Seeding and mulching shall be in accordance with the requirements and recommendations of the Land Quality Section of the Division of Land Resources.

4.4.10.4 The site shall feature ample turn around areas for service vehicles and a fourteen foot (14') minimum width stone access road which extends to and meets the grade of a public road or street. The turn around areas and the access road shall have a minimum of six inches (6") of compacted ABC stone.

4.4.10.5 All pump controls, pump and valve vault hatches, and other access points to equipment vulnerable to vandalism shall be secured by a padlock or other locking device subject to the approval of the Commission.

4.4.10.6 The site shall be provided with a high pressure sodium vapor luminaire light of 600 watt (minimum) capacity placed so as to illuminate the station area.

4.4.10.7 Installation of the pumps, controls, and related equipment shall be performed in accordance with the written instructions of the manufacturer.

4.4.11 Roadway, Street and Railway Crossings

Refer to Section 3.4.15 of the Manual for the requirements for crossings. In addition to the requirements of Section 3.4.15, all gravity sewer main carrier pipe shall be supported in the casing by means of a steel spider assembly. (See Standard Details)

4.5 TESTING OF SEWER SYSTEM EXTENSIONS

4.5.1 General

4.5.1.1 The Contract Documents for sewer system extensions shall provide for written requirements for thorough testing of new sewers and appurtenances.

4.5.1.2 All final testing and inspections shall be performed in the presence of the Commission's Representative unless otherwise directed by the Commission.

4.5.1.3 The Contract Documents shall require the Contractor to provide all pumps, gauges, instruments, test equipment and personnel required for inspection and testing operations.

4.5.1.4 The Contractor shall be required by the Contract Documents to clean and pretest the sewer system extension prior to notifying the Commission and arranging for final inspections and tests.

4.5.1.5 Materials removed to correct deficiencies revealed by tests and inspections shall not be reused. Pipe removed due to faulty grade shall be replaced with new pipe.

4.5.2 Test Sequence

The following test sequence shall be included in the Contract Documents for all wastewater system extensions unless otherwise permitted by the Commission.

- (1) Perform a visual inspection.
- (2) Correct defects revealed by visual inspection.
- (3) Perform leakage testing.
- (4) Make any necessary repairs.
- (5) Make the necessary retests.
- (6) Perform deflection testing (PVC SDR 35)

4.5.3 Visual Inspection for Gravity Sewers

Gravity sewers shall be visually inspected from every manhole by use of mirrors, television cameras, or other devices. The lines shall appear circular in cross section with no noticeable deflection. Lines which do not meet specified tolerances or which have structural defects shall be replaced to meet the requirements of the Commission prior to leakage testing.

4.5.4 Leakage Testing for Gravity Sewers

Unless otherwise permitted or required by the Commission, leakage testing for gravity sewers shall be by low pressure air test. Infiltration or exfiltration testing of the lines in lieu of air testing shall not be accepted without prior written approval of the Commission. All visible leaks shall be corrected regardless of the results of testing. All services, including those which discharge directly into manholes, shall be leakage tested.

4.5.4.1 Air Test

4.5.4.1.1 All air used for testing shall pass through a single, above ground control panel visible to the Commission's Representative during testing.

4.5.4.1.2 The Contract Documents shall require the groundwater elevation to be determined at 1000- foot intervals unless otherwise permitted or required by the Commission. Determination of groundwater elevation shall be made by vertically installing a six-inch diameter pipe beside the manhole such that the pipe extends into the stone bedding of the manhole. The test pressure shall be increased 0.43 psig per foot of groundwater head above the pipe invert.

4.5.4.1.3 The test pressure shall be 4.0 psig, plus the adjustment for groundwater. The air pressure shall be maintained for a minimum of two (2) minutes by throttling the air supply. The air supply shall then be disconnected and the pressure allowed to drop. At any convenient point at which internal air pressure is greater than 3.5 psig, (plus groundwater adjustment), timing shall commence with a stop watch or other timing device that is at least 99.8% accurate. The time required for the pressure to drop 1.0 psi shall be recorded.

The leakage rate shall be considered acceptable if the pressure does not drop over 1 psi in the time prescribed for the test in Table 4-4. Otherwise, the leakage rate shall be considered unacceptable.

4.5.4.1.4 The Contract Documents shall prohibit manhole entry during the test. The internal pressure on the system shall not exceed 9.0 psig.

4.5.4.1.5 Sewer service lengths shall be ignored for computing required test times for mains. In the event a test section, having a total surface area less than 625 square feet, fails to pass the air test when services have been ignored, the test time shall be recomputed to include all services using the following formula:

TABLE 4-4
MINIMUM TEST TIME FOR VARIOUS PIPE SIZES

1 Pipe Dia. (inch)	2 Minimum Time (min:sec)	3 Maximum Length For Minimum Time (ft)	4 Time for Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)								
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft	
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04	40:04
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41	57:41
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33	102:33

$$T = 0.085 \frac{(D1)(D1)L1 + (D2)(D2)L2 + \dots (Dn) (Dn) Ln}{D1L1 + D2L2 + \dots + DnLn} \frac{K}{Q}$$

Where T = Shortest allowable time, in seconds for the air pressure to drop 1.0 psig;

K = 0.000419 (D1L1 + D2L2 + ... DnLn), but not less than 1.0;

Q = 0.0015 cu. ft/min./sq. ft. of internal surface;

D1, D2, ...Dn = Nominal diameters of the different size pipes being tested in inches.

L1, L2, ...Ln = Respective lengths of the different size pipes being tested in feet.

If the recomputed test time is short enough to allow the section to pass, the section undergoing the test shall have passed.

4.5.4.2 Infiltration Test

Infiltration testing shall be an acceptable test method only when the ground is fully saturated and the area is not subject to flooding. Immediately prior to performance of the line acceptance test, the groundwater level shall be determined by the same method used for the air test (see Section 4.5.4.1.2). The allowable infiltration rate shall be fifty (50) gallons per inch of pipe diameter, per mile of pipe, per twenty-four (24) hours.

4.5.4.3 Exfiltration Test

The exfiltration test pressure shall be the greater of the following:

- (1) the maximum depth of the sewer test section as measured from the ground surface, plus the groundwater height above the lowest invert of the test section, or;
- (2) the 100-year flood elevation minus the lowest invert elevation of the test section, plus the ground water height above the lowest invert of the test section.

The exfiltration of the line shall not exceed fifty (50) gallons per inch of pipe diameter, per mile of pipe, per twenty-four (24) hours. The length of the test period shall be as required by the Commission, but in no case less than fifteen (15) minutes. Where a stream is not readily available as a source of water to use for testing, the commission may agree to provide water. Proper procedures for requesting operation of valves and hydrants will be required.

4.5.4.4 Deflection Testing of Gravity Sewers (PVC SDR 35)

All PVC SDR 35 sewer pipe shall be tested for deflection using a rigid device (mandrel) sized to pass 5% or less deflection (or deformation) of the pipe.

4.5.4.4.1 The mandrel shall be hand pulled by the Contractor in the presence of the Commission Representative, unless directed otherwise by the Commission. Any sections of the sewer not passing the mandrel shall be uncovered and the Contractor shall repair the sewer to

the satisfaction of the Commission. Repaired sections shall be retested in accordance with the provisions of this Section.

4.5.4.4.2 Deflection testing shall be conducted no earlier than 30 days after reaching final trench backfill grade, provided in the opinion of the Commission that sufficient water densification or rainfall has occurred to thoroughly settle the soil throughout the entire trench depth. If this cannot be achieved in the time after installation prior to the project completion date, the mandrel size shall be increased to measure 1/3 less of a deflection allowance.

4.5.4.4.3 The mandrel device shall be cylindrical in shape and constructed with nine or ten evenly spaced arms or prongs. Mandrels with less than nine arms will not be approved for use. The dimensions of the mandrel shall be as listed in the table below. The diameter of the mandrel shall carry a tolerance of plus or minus 0.01 inch.

<u>Nominal Diameter</u>	<u>Contact Length</u>	<u>Mandrel Diameter</u>
8"	8"	7.28"
10"	10"	9.08"
12"	12"	10.79"
15"	12"	13.20"
18"	15"	16.13"
21"	16"	19.00"
24"	17"	21.36"
27"	18"	24.06"

Allowances for piping wall thickness tolerances or ovality (from heat, shipping, poor production, etc.) shall not be deducted from the "D" dimension but shall be counted in as a part of the 5% or lesser deflection allowance.

4.5.4.4.4 Contact length shall be measured between points of contact of the mandrel arm. This length shall not be less than that shown in the table above.

4.5.4.4.5 The mandrel may not be used until approved by the Commission. Proving rings provided by the Contractor shall be used to assist in obtaining this approval.

Drawings of the mandrel with complete dimensions shall be furnished by the contractor to the Commission for each diameter and specification of pipe.

4.5.4.4.6 The mandrel device shall be as manufactured by H and H Fabricating of Fairfield, Ohio, Wortco, Inc. of Franklin, Ohio or Hurco Technologies, Inc of Harrisburg, South Dakota and shall be approved by the Commission.

4.5.4.5 Manhole Testing

4.5.4.5.1 The Contract Documents shall require each manhole to be tested for leakage after assembly and prior to backfilling. The test method shall be the vacuum test.

4.5.4.5.2 The Contractor shall provide all materials, labor, and equipment necessary to perform the testing. Testing equipment shall be subject to approval by the Commission.

4.5.4.5.3 The Commission shall be contacted prior to testing to schedule the test time such that the Commission's Representative may be present. The Commission's Representative shall be present during all testing unless otherwise approved by the Commission.

4.5.4.5.4 All lift holes shall be plugged from the outside with an approved non-shrink grout.

4.5.4.5.5 All pipes entering the manhole shall be plugged, taking care to securely brace the plug from being drawn into the manhole.

4.5.4.5.6 The test head shall be placed at the inside of the top of the cone section and the seal inflated in accordance with the manufacturers' recommendations.

4.5.4.5.7 A vacuum of ten inches (10") of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to nine inches (9"). The manhole shall pass if the time is greater than sixty (60) seconds for forty-eight-inch (48") diameter, seventy-five (75) seconds for sixty-inch (60"), and ninety (90) seconds for seventy-two-inch (72") diameter manholes.

4.5.4.5.8 If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn. Retesting shall proceed until a satisfactory test is obtained.

4.5.4.5.9 All visible leaks shall be corrected regardless of the results of testing.

4.5.4.5.10 All leaks shall be repaired in a manner approved by the Commission.

4.5.5 Testing and Cleaning of Force Mains

Force mains shall be cleaned and tested in accordance with the procedures for cleaning and testing water mains given in Sections 3.5.4 and 3.5.5. The allowable leakage shall not exceed the limits given for water mains and any visible leaks shall be repaired regardless of the results of testing. When repair work is necessary to correct leakage, the hydrostatic test shall be repeated upon completion of the work.

4.5.6 Testing and Start-up of Pumps

4.5.6.1 The pumps shall be run under actual field conditions demonstrating that the pumps perform as specified in the Contract Documents. Any deficiencies disclosed by the pump start-up shall be corrected prior to project acceptance.

4.5.6.2 Two (2) copies of the operation and maintenance Manual and two (2) copies of the electrical schematic for the pumps and controls shall be provided to the Commission two (2) weeks prior to the date of the start-up test.

4.5.6.3 Start-up shall be performed by the manufacturer's representative in the presence of the Commission's Representative.

4.5.6.4 The manufacturer must submit a certified report of the pump field start-up performance (electrical and hydraulic) to the Commission as a condition of project acceptance.