Appendix A Water & Sewer Design

(Revised 2/10/17)

1.1 GENERAL

1.1.1 SPECIFICATION AND DESIGN MANUAL

All projects within the jurisdiction of the City of Lynchburg shall be designed and constructed in accordance with the City's Manual of Specifications and Standard Details, latest revision.

1.1.2 ENGINEERING REPORT REQUIREMENTS

When required by the City Engineer and prior to proceeding with design, the developer shall be required to provide a brief Engineering Report satisfactory to the City Engineer, which shall define:

A. The service area limits, design flows and capacities of the utility extension under question.

B. The development area limits and percentage of line capacity utilized by the developer.

1.1.3 DESIGN REPORT REQUIREMENTS

A Design Report is required to be submitted with each project involving water and sewer system construction by the Engineer. The report shall include the following items at a minimum:

A. **Water Project**

1) Pipe location,
2) Pipe material,
3) Pipe diameter,
4) Pipe length,
5) Design population (or number of connections),
6) Pressure calculations:
   a. Before the project
   b. after the project, and
7) Demonstrate that residual pressures greater than 20 psi can be maintained,
8) Water meter sizing determination information/basis.

B. **Sewer Project**

1) Pipe location,
2) Pipe material,
3) Pipe diameter,
4) Pipe length,
5) Design population (or number of connections),
6) Design flow,
7) Sewer shed.

1.2 WATER SYSTEM DESIGN STANDARDS

The purpose of this module is to establish standard design procedures and criteria for water system design in the City of Lynchburg.

1.2.1 FIRE DEMAND

Demand forecasting projects the future water use based on historic use factors, socioeconomic trends, climatic factors and other parameters. Distribution system design must also account for peak periods of daily use. Peak factors are a function of land use, present population, and population growth rate. Older established areas tend to have peak factors two to three times lower than those of rapidly expanding areas. Although the overall volume of water used for fighting fires is quite low relative to most other uses, the rate at which it must be supplied places a heavy, short-term drain on the system.

The estimated fire flow can be established using the Insurance Services Office (ISO) “Guide for Determination of Needed Fire Flow,” latest revision or NFPA, or International Fire Code Appendix B, latest revision. All TRC projects shall have fire flows calculated and submitted to the City Fire Marshall and City Engineer for approval during the TRC process. The calculations shall include calculations verifying the required fire flow and pressures can be achieved. All calculations shall be sealed by a professional engineer. Calculations for subdivisions shall be submitted during the RWS plan review process.

A Site Design manual is available at the City’s website, www.lynchburgva.gov. From the City website click the tabs in the following order: “City Departments”, “Fire Department”, “Fire Marshall’s Office”, and “Site Design Requirements”. Download the PDF entitled “Site Design Requirements Fire Apparatus Spacing and Water Specifications”.

1.2.2 DISTRIBUTION SYSTEM

A. **General:** Distribution systems shall meet the minimum requirements of **The Code of Virginia, Commonwealth of Virginia, Department of Health**, latest revision.

The subdivider shall connect the subdivision with the municipal water system at his expense, and shall construct it in such a manner as to serve adequately for both domestic use and for fire protection on all lots shown on the Subdivision Plat for any development either within the corporate City Limits of Lynchburg,

according to Chapter 24 (24.1-19, 20, 21, 21.1) Subdivisions of City of Lynchburg Code.

B. **System Design:** As part of the design, the City Engineer may require the Engineer to model new portions of the system using the ***University of Kentucky*** **Kentucky Pipe** or **WaterCAD** software. When using a water distribution model, the following conditions shall be used.

1) Pipe shall include a pipe roughness C of 120, indicating future conditions in the pipe.
2) Pipe lengths and diameters and junction elevations shall be as indicated on the water line plan and profiles.
3) Junction nodes shall be provided at any intersection of water pipe, excluding individual residential service connections, any change in pipe diameter, and at all fire hydrants.
4) Domestic demands shall be applied for all current and future connections. For each residential connection, an average demand of 700cf/month shall be applied. Non-residential demands shall be determined by the engineer based on the proposed use. All demands shall be applied to the nearest junction node.
5) Fire flow conditions shall be modeled under the maximum daily flow conditions combined with a fire flow. This may be simulated by using a typical diurnal curve flow pattern in an extended period simulation, or applying a 1.5 peaking factor on the average daily domestic demand. Model fire demand conditions with water tanks or reservoirs (static pressure) at the lowest operating condition. Fire flows shall include the required sprinkler flows, if any, with a 500-gpm hose flow at the nearest fire hydrant.

The water distribution model shall be provided to the City of Lynchburg saved as a WaterCAD Drawing File or as an EPAnet File (.inp).

The design data shall include a sketch of the system showing assumed minor losses, pipe roughness, line lengths, fixed grade node elevations, node numbers, demands, pipe numbers, time of day of field test of hydrant (static pressure converted to elevation head) for verification of starting elevation head, the static water elevation in tank at the time a static pressure reading was taken, and ground elevation of hydrant tested.

C. **Piping Applications**

General: Use pipe, fittings and methods of joining in accordance with the following:

1) **Pipe that May be Used Underground**:

a. **Water Mains**: 6-inch to 48-inch Ductile Iron Pipe

b. **Services**: 3/4-inch to 2-inch Type K Copper,

c. **Services greater than 2-inch:** Ductile Iron Pipe

2) **Pipe that May be Used Above Ground**:

a. **Water Mains**: 6-inch to 48-inch Ductile Iron Pipe

D. **Joint Applications**

1) For underground applications, use push on or mechanical joints for 3-inch pipe and larger.

2) For above ground or vaults, use flanged end joints.

3) Provide transition couplings and special fittings with a pressure rating equal to or exceeding the pressure rating of the pipe or fitting to which they will be either connected or fitted.

4) Do not use flanges, unions, or keyed couplings for underground piping.

E. **Location**: Water mains shall be located within dedicated street rights-of-way or City utility easements. Water mains should, if possible, be located no closer than 5 feet from the lip of the curb.

F. **Pressure:** Water distribution mains shall be sized to provide a minimum pressure at all points within the distribution system of not less than 20 psi (gauge) based on the greater of maximum hour or maximum day plus applicable fire flows.

G. **Pressure Reducing Valves (PRVs)**: When the maximum static pressure in a new system exceeds **80 psi**, businesses and/or residences shall be equipped with a pressure-reducing valve. The valve shall be located on the outlet side of the meter. It is the property owner's responsibility to install and maintain the PRV.

H. **Pipeline Velocity**: 3 to 6-fps normal working conditions are preferred. Sustained high discharge velocities can scour the pipe's interior and increase leakage. Minimum velocity must be maintained to prevent sediment accumulation and bacteriological growth.

I. **Main Size:** Minimum main size is 8 inches in diameter with fire hydrant lead-ins being at least 6 inches in diameter. A 6-inch diameter main may be used in dead end or cul-de-sac locations provided that the block is less than 500 feet in length and that no potential for future water main extension is likely. However, a fire hydrant, in accordance with **Standard Detail 26.09**, will be required at the end of the 6-inch line. If the line can be extended in the future, as determined by the City Engineer, a temporary blow-off may be installed at the end of the line in accordance with **Standard Detail 26.10**.

J. **DIP Minimum Thickness Class**:

Table 3.1

6” to 12”	class 50
14” to 20”	class 50
24”	class 50

K. **Allowable Leakage:** See also Table I of specification Section 02660 – *Water Distribution*, paragraph 3.4.1, “Pressure Tests and Leakage.”

L. **Bury**: Under conditions which otherwise prevent minimum bury from being achieved, such as at crossings above shallow buried structures or rock, the minimum cover shall be no less than one foot less than minimum bury requirements, as approved by the City Engineer. See specification Section 02660 – *Water Distribution* and specification Section 02220 – *Trenching, Backfilling, and Compaction of Utilities*.

M. **Dead End Lines** must have either a fire hydrant or blow-off assembly for flushing. However, the City Engineer must first approve the use of a blow-off assembly. 2-inch blow-off assemblies (**Standard Detail 26.10**) are typically to be used in situations where an extension to the end of an 8-inch or larger line is expected to be made. A fire hydrant shall be placed in accordance the **Standard Details 26.08 and 26.09**.

N. **Sag Verticals**: Provide a fire hydrant as a sag blow-off when lines have a severe sag (such as when running beneath large streams, ditches or culverts where sediment can accumulate and retard flow in water line). Eliminate localized sags as much as possible. When a fire hydrant cannot be used as a sag blow-off, a blow-off hydrant may be allowed upon approval of the City Utilities Engineer.

O. **Crest – Air/Vacuum Release Valves (ARVs)**: Provide an ARV at all high points. The water line shall be designed and constructed to minimize localized high points.

P. **Allowances for Main Expansion of Aerial Crossings**: Install expansion devices as necessary to allow expansion and contraction movements such as on aerial crossings. Provide insulation on exposed pipe.

Q. **Fire Hydrants:** Fire hydrants shall not be installed on water mains of less than 8 inches in diameter. See **Standard Detail 26.09**.

1) **Fire Hydrant Location Guidelines**: Mid block hydrants will not be allowed unless approved by the City Engineer. Street hydrants shall be located either at the end of cul-de-sacs or at intersections.

2) All hydrants are to be located in the street right-of-way or in a City of Lynchburg Utility Easement.

3) **Minimum Fire Flow at Hydrants:** All hydrants: 500 gpm at 20-psi residual pressure.

4) **Maximum Distances from Structures:** Per 2003 International Fire Code Section 508 and Appendix C. All distances shall be measured by the lay of the hose and not in a straight line.

5) **Maximum Distances between Hydrants:** Per 2003 International Fire Code, Appendix C, Table C105.1 for all development within the City. The maximum distance between hydrants in new subdivisions shall be 500 feet. All distances shall be measured by the lay of the hose and not in a straight line.

6) **Hydrant in Relation to Street:** See **Standard Detail 26.09**.

7) **Hydrant Location in Relation to Siamese Connection:** A hydrant shall be placed on the "supply" side of the Siamese connection no more than 50 feet from the Siamese connection to allow the fire suppression personnel to charge the closed system. The hydrant must be completely accessible for truck pumper connection.

R. **Valving**: Valves shall be installed at all branches from feeder mains and between mains and hydrants according to the following schedule:

1) Three valves at tees (except hydrant branches made on mains),

2) Four valves at crosses,

3) When downsizing a main, locate a valve after the reducer on the side with the smaller diameter. However, the designer must evaluate thrust forces and accommodate the forces by placement of a thrust collar (if required) on the larger main.

4) Valves on main distribution line runs shall not exceed the distance given below in Table 3.2. Where possible, main line valves shall not be located more than 50 feet from the nearest fire hydrant with a maximum spacing between valves as given below in Table 3.2.

Table 3.2

Main Size	Maximum Spacing
8-inch	1000 feet
12-inch	1000 feet

5) Valves on transmission main runs shall not exceed the distance given below in Table 3.3.

Table 3.3

Main Size	Maximum Spacing
16-inch or greater	2000 feet

S. **Relation of Water Mains to Sewers**
See specification Section 02660 – *Water Distribution*, Part 1 – General, paragraph 1.8 "Project Conditions" for separation requirements between water mains and sewer mains/manholes and water mains and drainage structures/streams.

T. **Meter Location – Double Frontage Lots**: If a lot fronts on 2 or more streets, the meter shall front the same street as the lot's address. Refer to the City of Lynchburg Service Installation Procedure.

U. **Cross-Connection Prevention**
Refer to the City of Lynchburg's Cross-Connection and Backflow Prevention Program and the City of Lynchburg's Manual of Specifications and Standard Details, Latest Revisions. Contact the Department of Water Resources, City Compliance Specialist at (434) 455-4261 for information and assistance.

V. **Connecting Varying Pressure Zones:** Where 2 different pressure zones are connected, a Pressure Reducing Station may be required or a gate valve shall be set and a division marker placed in the valve box per **Standard Detail 26.17**.

W. **Testing**

See specification Section 02660 – *Water Distribution* for testing requirements.

X. **Thrust Block Anchors and Mechanical Thrust Restraint**

Concrete thrust block anchors, tie rods, restrained joint pipe, and/or other means of restraint shall be provided at all changes in pipe size and pipe direction.

Concrete thrust block anchors are not recommended where the blocking may bear on other utilities or where the area behind the block may be excavated in the future. See **Standard Detail 26.04**.

Mechanical thrust restraint systems may be used in lieu of anchor blocks. Restraint must be applied at all tees, bends, reducers, valves, and dead ends. Mechanical thrust restraint shall be designed to the standards set forth by the Ductile Iron Pipe Research Association (DIPRA) publication "Thrust Restraint Design for Ductile Iron Pipe", latest edition and amendments.

Design of restrained joint systems may be based on the DIPRA model, Thrust Restraint Design for Ductile Iron Pipe, available for free download from the DIPRA web site (www.dipra.org). When designing a restrained joint system, the engineer shall use Trench Class 4 with a minimum safety factor of 1.5. Depth of cover and soil conditions shall be based on actual field conditions proposed in the design. When calculating the restrained joint length or number of joints, all values shall be rounded up to the next pipe joint.

Y. **Water Meter Sizing**

All water meters shall be sized in accordance with the latest revision of AWWA M22. Determination of meter sizing and specification of meter shall be made by

a Virginia licensed Professional engineer or architect or fire suppression specialist. Meter size shall be approved by the Water Resources Meter Supervisor at (434) 455-4259.

Z. **Manholes for Valves**

Manhole Cones: Eccentric cones are preferred in all cases.

AA. **Public Easements**

The width of easements (except when adjacent and parallel to right-of-way) shall be 20 feet. Consideration shall be given for deeper cuts (generally greater than 12 feet) by including an additional temporary construction easement (usually 10 feet). The City Engineer may require that the width of the permanent easement increase with the depth of water line and/or with the diameter of the water line for maintenance purposes.

Easements shall be fully accessible by rubber-tired vehicles in their entirety. The City may require stream fords. Stream fords shall be provided as specified in paragraph 1.3.5 E, *Fording Streams,* below.

1.3 GRAVITY SANITARY SEWER COLLECTION SYSTEM DESIGN STANDARDS

The purpose of this module is to establish standard design procedures and criteria for sewer system design in the City of Lynchburg.

1.3.1 GENERAL

A. **General:** Gravity Collection systems shall meet the minimum requirements of **Virginia Department of Environmental Quality** (DEQ) and the Virginia Administrative Code, Article 1, **Collection and Conveyance Sewers**, 12VAC 5-581-370, 380, 390, and 410, latest revision.

The subdivider shall be required to connect his subdivision with the municipal sewage system at his expense according to Chapter 24 – Subdivisions of the City of Lynchburg Code.

B. **System Design**: The system is to be designed for the estimated ultimate tributary population including consideration given to the maximum anticipated capacity of institutions and industrial parks, etc. The capability of the downstream sewers to accept the future flow from tributary collection systems shall be evaluated by the design engineer. Wastewater flows shall be determined in accordance with Article 1, **Collection and Conveyance Sewers**, 12 VAC 5-581-370.

1.3.2 DEFINITIONS

A. **Definitions:** For the purposes of this specification, the following definitions refer to sanitary sewer collection systems that come under the authority of the City of Lynchburg, Virginia as specified within this section and other sections of this manual.

1) **Main or Trunk Sanitary Sewer**: Exterior gravity sanitary sewer systems receiving flow from one or more laterals or mains.

2) **Sewer Service (lateral)**: Exterior domestic sewer piping serving a private residence, business, commercial facility or industrial user.

3) **Interceptor**: Sewer that receives flow from a number of gravity mains or trunk sewers, usually placed along a stream or river.

B. The following are industry abbreviations for various pipe materials:

1) **DIP**: Ductile Iron Pipe

2) **PVC**: Polyvinyl Chloride Plastic

3) **RCP**: Reinforced Concrete Pipe

1.3.3 COLLECTION SYSTEM DESIGN

A. **Minimum Size/Sizing:** No public gravity sewer conveying wastewater shall be less than 8 inches in diameter.

All sewer mains should be sized to serve the total natural drainage basin. Sewer size design shall be based on average daily flow of 100 gallons per capita daily (gpcd). The minimum peak design capacity of the main and trunk sewers shall be 250% of the average daily flow. The minimum peak design for interceptor sewers shall be 200% of the average daily flow. These factors include infiltration but exclude inflow. If inflow is anticipated or known to exist in upstream sewers, the City Engineer may require that the design flow be increased accordingly and the justification/computation/source referenced in the design calculations shall be provided to the City Engineer for review.

B. **Acceptable Pipe Material**

1) Refer to Part 2 - PRODUCTS of Section 02730 – *Sanitary Sewer* for detailed specifications for pipe and fittings. Use pipe, fittings, and joining methods according to the application indicated. Also refer to Section 02220 – *Trenching, Backfilling, and Compaction of Utilities*, paragraph 3.3.

In the system design, the engineer should consider control of hydrogen sulfide generation through system design and/or use of corrosion resistant high alumina (calcium aluminate) pipe linings. See also paragraph 1.3.3.H.5 – High Velocity Protection, below.

2) VCP is not allowed.

C. **Location:** All sewer mains shall be installed within the street right-of-way or within a dedicated sewer or utility easement. Preferably, the sewer shall be located outside of the pavement. Where the sewer cannot practically be located outside of the pavement, the sewer shall be located in the center of a travel lane and out of the wheel path.

1) Deflection angles for all horizontal turns shall be shown and elevations shall be tied to mean sea level reference datum, including benchmarks. Plans must show manhole number, top elevations, station, slope, and depth along with invert elevations.

2) Where tributary flow is expected from an upstream natural drainage basin, designers shall provide extensions of sewer mains to the farthest property line of the tract.

3) Sewers paralleling creeks shall be below the stream elevation, such that lateral connections will be below streambed (**Standard Detail 27.19**). In certain circumstances where rock is present, sections of the main may be raised to allow lateral connections above the stream bed provided the ability to serve the upstream property is not compromised and the pipe crossing is designed sufficiently restrained to prevent line breakage (see **Standard Details 27.17** and **27.18**) by the dynamic affects of the stream flow.

D. **Service Connections**

1) Services connected to gravity sewers shall be connected using in line wyes only. Service saddles may be used on existing mains. All wyes shall be embedded in stone. See **Standard Details 27.14** and **27.16** for service tap detail.

2) A cleanout will be installed on each house service. Unless topography prohibits, place services at low side of lot.

3) The cleanout shall be located at the right of way or the easement line on the City side of the property line as shown on **Standard Detail 27.15**.

4) See **Standard Detail 27.15** for service lateral slopes.

5) Vertical stacks or standpipe services are not allowed.

6) Service connections to manholes will not be allowed.

7) Plans must include a lateral table showing the following: invert at main, invert at clean out, invert at structure, and lowest floor elevation served by gravity.

8) Food Service Establishments and Petroleum Using Establishments shall comply with requirements stated in the City's Fats, Oil and Grease Program. The current requirements of this program are detailed on the Department of Water Resources website.

E. **Public Easements**

The width of easements (except when adjacent and parallel to right-of-way) shall be 20 feet. Consideration shall be given for deeper cuts (generally greater than 12 feet) by including an additional temporary construction easement (usually 10 feet – 50 feet). The City Engineer may require that the width of the permanent easement increase with the depth of sewer line and/or with the diameter of the sewer line for maintenance purposes.

Easements shall be fully accessible by rubber-tired vehicles in their entirety. The City may require stream fords. Stream fords shall be provided as specified in paragraph 1.3.5 E, *Fording Streams,* below.

F. **Depth/Minimum Cover**: A minimum of 4 feet of cover shall be provided for all sewers unless ductile iron pipe is specified. Ductile iron pipe, or other pipe with proper casing shall be provided where sewers are subject to traffic bearing loads.

The depth of sewer mains should be such that they are deep enough to serve all upstream properties within the drainage basin.

G. **Buoyancy:** Buoyancy of sewers shall be considered and flotation of the pipe shall be prevented with appropriate construction where shallow cover and high groundwater or flooding conditions are anticipated. For design purposes, assume water to top of pipe and pipe is empty.

H. **Slope**

1) **General**: All sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Manning's formula using an "n" value of 0.014. The following are the minimum slopes that shall be provided; however, slopes greater than these are recommended.

2) **Minimum Slopes:**

Table 3.4

Sewer Size (inches)	Minimum Slope (%)
8	0.50
10	0.28
12	0.22
15	0.15
16	0.14
18	0.12
21	0.10
24	0.08

a. **Uniform Slope Between Manholes**: Sewers shall be designed with uniform slope between manholes.

b. **Slope Increase**:

i. On upper reaches of small services and mains, due to water saving fixtures now employed, the designer should give consideration to increasing the slope of gravity services above the minimum allowed in order to flush solids.

ii. Special attention must be given to the fact that initial flows may be substantially lower than design flows and the velocities well below the minimum. The designer, or the City Engineer may direct usage of greater slope.

3) **Minimum Velocity/Solids Deposition**: The pipe diameter and slope shall be selected to obtain the greatest velocities to minimize settling problems. Designs must include a minimum scouring velocity of 2.0 fps.

a. **Pipe Size Increase**: Sewers shall not be oversized to justify flatter slopes. If the minimum scouring velocity cannot be maintained during initial operation prior to the design flow capacities being reached, the developer may be required to periodically flush the system until volume has increased to effect self-scouring occurs.

b. **Slope Decrease**: With the permission of the City Engineer, decreased slopes may be permitted provided it can be proven that the depth of flow will be equal to or greater than 0.3 of the pipe diameter for the average daily flow. The City Engineer will require computations of the depth of flow in such pipe at minimum, average, and peak daily or hourly rates of flow.

4) **Maximum Slope/Steep Slope Protection**: Grades greater than 20% should be avoided if possible. Any time the grade is greater than 20%, ductile iron pipe should be used (see paragraph 6 of this section “Steep Slope – Pipe Anchorage” below).

5) **High Velocity Protection**: Where design velocities are projected to be greater than 15 fps, the sewer lines shall be protected against internal erosion and impact by high velocity. Pipe shall conform to ASTM, AWWA, ANSI, etc. which provide protection against erosion.

6) **Steep Slope – Pipe Anchorage**: Sewers constructed on 20% or greater slope shall be anchored both to prevent the sewer pipe from creeping downhill and/or to prevent water from flowing along the pipe and causing the trench to wash out. The lines shall be securely anchored with concrete anchors (see **Standard Detail 27.21**). Suggested minimum spacing of anchors shall be as follows:

Table 3.5

Grade Range (% slope)		Anchor Spacing (center to center in feet)
From	To	
20	<35	36
35	<50	24
50	Or greater	16

I. **Alignment:** All sewers shall have a straight alignment between manholes.

J. **Changes in Pipe Size or Material**:

1) **Pipe Size Changes**: Gravity sewer sizes shall remain constant between manholes. In manholes with smaller upstream sewer line and larger downstream line, the crowns of the two sewer lines shall match.

2) **Undersized or Substandard Downstream Sewers**: Contact the City Engineer for design considerations.

3) **Pipe Material Changes**: To avoid couplings of dissimilar material, pipe material must remain consistent between manholes and may not be changed. See **Standard Details 27.04** and **27.05**. In some cases, it may be necessary to have dissimilar materials join at drop manholes. In this case, the joint shall occur where the main approaches a drop manhole.

K. **Testing and Allowable Leakage:** See specification Section 02730 – *Sanitary Sewer* for testing requirements.

1.3.4 DESIGN – MANHOLES

A. **Location**

Manholes shall be installed on all mains 8 inches and larger, manholes shall be installed at the end of each line, at all changes in grade, at changes in pipe material, at changes in main size or alignment, at all intersections and at distances not greater than 400 feet for all sewers 15 inches or less in diameter. For sewers 18 inches to 30 inches in diameter, 500-foot spacing may be used.

B. **Diameter**

1) **Minimum Diameter**: The minimum diameter of manholes shall be 4 feet.

2) **Diameter Based on Pipe Size**: Manholes shall be 4-foot minimum diameter for lines up through 27 inches for a straight run (2-inch through 27-inch diameters).

3) **Diameter Based on Depth**: Manholes 0 to 20’-0” shall be 4 feet in diameter minimum. Manholes greater than 20 feet deep shall be 5 feet in diameter. Manholes over 12 feet deep shall have appropriately designed extended bases. Manholes greater than 20 feet in depth may be transitioned, at the 20-foot depth, from a 5-foot diameter to 4-foot

diameter manhole except after a minimum of 5 feet of riser (height) from invert of manhole.

4) **Cones**: Eccentric cones are preferred in all cases.

5) **Minimum Drop Across Invert**: The minimum drop between manhole invert in and invert out is 0.10 feet on straight junctions and 0.25 feet at 90º horizontal turns.

C. **Drop Type**

1) A drop shall be provided for a sewer entering a manhole at an elevation of 2 feet or more above the invert of the manhole, unless pipe crown elevations match.

2) **Inside Drops:** For existing 4-foot manholes, an inside drop will be permitted. See **Standard Detail 27.04.** An inside drop will be permitted on new manholes 5 feet or greater in diameter.

3) **Outside Drops:** Outside drops will be permitted for new and existing lines only with the approval of the Utilities Engineer. See **Standard Detail 27.05**.

D. **Doghouse Manhole**

Manholes placed over existing mains shall be constructed in accordance with **Standard Detail 27.07**.

E. **Water-tightness**

1) Manholes shall be pre-cast concrete.

2) **Pipe Connections to Manholes**: Inlet and outlet pipes shall be joined by core drilling to the manhole with gasketed flexible watertight connections (rubber boots). See **Standard Details 27.02 through 27.05**.

3) All sanitary sewers shall be designed for protection from the 100-year flood by either of the following two methods:

a. Manholes shall be waterproof and vented 12 inches above the 100-year base flood elevation. Manholes shall be vented every 1000 feet or every third manhole, whichever is lesser, or

b. Manholes rims shall be 12 inches above the 100-year base flood elevation.

c. Where manhole rims are located above grade, flat top manhole sections shall be installed.

F. **Finish Top Elevation**:

1) See E3.b for flood plain conditions.

2) Manhole frame and cover shall be a minimum of 18 inches above surrounding finish grade in undeveloped areas. Flat top manhole section shall be installed.

3) Manhole frame and cover shall be installed flush with proposed final grade in developed/landscaped/lawn/paved areas.

G. **Buoyancy**: Buoyancy shall be considered and flotation of the manholes shall be prevented with appropriate construction where high groundwater or flooded conditions are anticipated. For design purposes, assume water to top of manhole and that the manhole is empty.

H. **Inspection and Testing**: See technical specification Section 02730 – *Sanitary Sewer* for testing requirements. See also Appendix C, *Procedures, Infrastructure Inspection and Acceptance for Maintenance* for other related requirements.

I. **Corrosion Protection for Manholes**

1) Where corrosion conditions due to septicity or other causes are anticipated, corrosion protection shall be provided protection on the interior of the manholes. Consequently, drops in interceptor lines or drops into interceptor lines shall be avoided. Drop manholes, if required, shall be provided upstream of interceptor line connection.

2) Where influent pipes have a slope of greater than 10 percent, the manholes shall be protected against internal erosion by utilizing an outside drop connection to reduce the velocity or providing erosion resistant coatings, sacrificial concrete, or other approved means. Manholes shall also be protected against displacement from impact.

1.3.5 SEWERS IN RELATION TO STREAMS AND OTHER BODIES

A. **Cover Depth**: The top of all sewers entering or crossing streams shall be at a sufficient depth below natural bottom of the streambed to protect the sewer line. See **Standard Detail 27.19**.

B. **Structures:** The sewer interceptors, manholes, or other structures shall be located so they do not interfere with free discharge of flood flows of the stream. Portions of manholes above grade subject to hydrodynamic forces of flooding shall be designed to resist the flood forces with a safety factor of 2.5 considerations shall be given for impact from debris. See paragraph F below.

C. **Alignment**: Sewers crossing streams shall be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade.

D. **Materials**: Sewers entering or crossing streams shall be constructed of ductile iron pipe with mechanical joints or steel pipe. They shall be constructed so they will remain watertight and free from changes in alignment of grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel or other materials that will not readily erode, cause siltation, damage pipe during placement, or corrode the pipe.

E. **Fording Streams**: At locations where proposed sewers cross streams, ditches or swales, the stream shall be made passable to maintenance equipment with the installation of 24 linear feet of twin 36-inch RCP's (Based on Q_{25}). Ensure that the crossings are consistent with DEQ and USCOE requirements. For flows that exceed the capacity of the twin 36-inch pipes, use **Standard Detail 27.22**.

F. **Aerial Crossings**

1) Aerial pipe crossings shall be approved only at locations where a below-grade stream crossing is not feasible. The developer or engineer shall coordinate with the City's Department of Water Resources prior to submitting plans to discuss alternatives and demonstrate why an aerial crossing is the best possible design.

2) Pipe material for aerial pipe crossings shall be ductile iron or steel.

3) Proper joint technology, such as flanged or restrained mechanical joint, adequate supports to prevent excessive deflection and flexion or a combination of both shall be provided for all aerial pipe crossings.

4) Pipe supports shall be designed to prevent heave, overturning, uplift, and settlement. Pipe supports shall be designed and located at each length of pipe, located directly behind the pipe bell if using mechanical joints, or within two feet of the joint for flanged or welded joints. Supports shall be designed to withstand the hydrodynamic effects of the stream flow pressure using the following formula:

$$\mathbf{P = 1.5\ KV^2}$$

Where,
1.5 = safety factor against overturning (2.5 is recommended),
P = pressure, psf
V = velocity of water, fps
K = 4/3 for square ends, ½ for angle ends when angle is < 30° or less and 2/3 for circular piers.

If it is probable that the aerial pipe could be submerged by the stream flow, the effects of the flow pressure on the pipe shall also be taken into account when computing pier-overturning moments. For aerial stream crossings, the impact of floodwaters and debris shall be considered. In streams subject to flooding velocities greater than 5 fps, pipe crossing shall be anchored in bank in such a way that if all supports are lost, the pipe system will not separate and will be restrained by anchor blocking of

appropriate size in the bank. Provide applicable blocking computations and details.

5) Expansion jointing shall be provided between above ground and below ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize heaving.

6) The bottom of the pipe should be placed no lower than the elevation of the 25-year flood.

7) Aerial pipe crossings are to be coated.

8) See **Standard Detail 27.18**.

G. **Anti-Seepage Collars (Anchors) – Wetland Areas**: In areas where the sewer trench has the potential to drain wetlands, lakes, ponds, etc., anti-seepage collars shall be installed. In these areas, a 404 USCOE permit may be required.

1.3.6 PROTECTION OF POTABLE WATER SUPPLIES AND STORM SEWERS

A. **General**: See specification Section 02730 – *Sanitary Sewer*, Part 1- General, paragraph 1.9 "Project Conditions" for separation requirements between water mains and sewer mains/manholes and water mains and drainage structures/streams.

B. **Crossing Other Utilities**: When other underground utilities are encountered, (i.e. telephone lines, gas lines, cable TV, etc.) 12-inches of separation should be maintained.

C. **Sewer/Well Conflict**: If a sewer main is installed within 50 feet of an existing well, watertight joints meeting Virginia Department of Health requirements shall be employed in the sewer line for all portions of the sewer line within a 50-foot radius of the well.