CITY OF FORT SMITH

GRAVITY SANITARY SEWER MINIMUM DESIGN STANDARDS

March 2022

TABLE OF CONTENTS

1. SCOPE AND AUTHORITY

This document identifies the City of Fort Smith's minimum design requirements for public sanitary sewer infrastructure as defined by the State of Arkansas and the City of Fort Smith Municipal Code. While this document details the minimum design requirements for any improvements to the City of Fort Smith's public sewer infrastructure, it does not relieve the design engineer from providing sound professional judgement. All design documents shall conform to accepted engineering and surveying standards and safeguard the life, health, property, and welfare of the public as identified in Article 20 – Ethics and Rules of Professional Conduct from the Arkansas Board of Licensure for Professional Engineers and Professional Surveyors. The following referenced sections give authority to the City of Fort Smith to construct, maintain, and operate a sanitary sewer system along with associated ability to provide design and construction standards.

1.1 – A.C.A. § 14-235-203 – Authority of Municipalities

Every municipality in the State of Arkansas is authorized and empowered to own, acquire, construct, equip, operate, and maintain, within or without the corporate limits of the city or town, a sewage collection system or a sewage treatment plant, intercepting sewers, outfall sewers, force mains, pumping stations, ejector stations, and all other appurtenances necessary or useful and convenient for the collection and treatment, purification, and disposal in a sanitary manner of the liquid and solid waste, sewage, night soil, and industrial waste of the municipality.

1.2 – A.C.A. § 20-7-109 – Authority to Regulate Public Health

Power is conferred on the State Board of Health to make all necessary and reasonable rules of a general nature for the protection of the public health and safety; the general amelioration of the sanitary and hygienic conditions within the state; the suppression and prevention of infectious, contagious, and communicable diseases; the proper enforcement of quarantine, isolation, and control of such diseases; and the proper control of chemical exposures that may result in adverse health effects to the public.

1.3 – Arkansas State Board of Health – Rules Pertaining to General Sanitation (ADH-GS Section XII)

In the event that water or wastewater infrastructure improvements (hereinafter "infrastructure"), including those within an improvement district, are proposed to be constructed within the adopted territorial jurisdiction of a municipality under A.C.A. 14-56-413 or its designated utility service area, said municipality shall be provided notice of such a proposal prior to the commencement of any work, assessment, or indebtedness associated with same.

No infrastructure shall be connected to or serviced by a municipal utility unless and until same is expressly granted by the municipality, subject to the municipality's connection and/or extension policy, if any.

Any infrastructure improvements, including those within an improvement district, proposed to be constructed within the adopted territorial jurisdiction of a municipality under A.C.A. 14-56-413 or its designated utility service area, regardless of whether same is to be connected to or serviced

by a municipal utility, must be built according to the standard utility construction specifications, if existing, of that municipality and in compliance with the piping sizes required by the municipal utility. The municipal utility shall be granted access during all phases of construction in order to inspect and verify substantial compliance with their construction standards, specifications, and pipe size requirements during and following construction of the infrastructure improvements.

1.4 – City of Fort Smith: Section 27-505 – Sanitary Sewer

1. **Applicability.**
   No sanitary sewer facility shall be constructed, altered, extended, or reconstructed within a subdivision, planned development, or a developed area within the planning jurisdiction of the City of Fort Smith without first having the approval of the City of Fort Smith Utility Department and any required state agencies. All such construction shall meet the requirements included herein.

2. **General Requirements and Design Criteria.**
   Sewer systems shall comply with the City of Fort Smith Sanitary Sewer Standards, which document is included herein by reference.

Note: All designs shall conform to the most stringent requirement of any adopted code, ordinance, or standard from other governing agencies.

2. GENERAL DESIGN REQUIREMENTS AND PLANNING

2.1 – Licensure Requirements

All designs, plans, and specifications submitted to the City for approval for the construction of public utility improvements as required herein shall be prepared under the direction of a professional engineer, licensed in the State of Arkansas, and shall meet the minimum standards specified. *(A.C.A. 17-30-101)*

2.2 – Basis of Design Requirements

Upon application to the city for approval of development of a tract of land located in an entire drainage area as defined herein and when required by the city, land developers shall extend public sewer facilities to the city-owned trunk line or interceptor line or main determined to be adequate by the city. The required sewer facilities shall be of sufficient size to serve the entire drainage area in which the sewer facilities are to be constructed. The initial developer shall submit information indicating the size of the sewer facilities to be constructed and shall submit a map, certified to by an engineer licensed to practice in the state, depicting the size and boundaries of the entire drainage area and the size and boundaries of the initial development to the city for approval. Such sewer facilities shall not be constructed until approval has been given in writing by the city. The entire drainage area shall be located within the planning jurisdiction of the city. (*CFS 25-193(b)(1)*) Zoning information shall be provided on the map if used to develop design flows.

Computations should be presented in a tabular form for each segment of the system. Commentary shall be presented that details how design flows and peaking factors were developed.

A summary of the design criteria that shall be submitted with the basis of design. Additional items may be requested at the time of review.

1. Pipe segment identification
2. The identification of each manhole at the upstream and downstream portion of each segment
3. Total tributary area at each downstream portion of each segment
4. Peaking factor for each segment
5. Design Flow for each segment (including flow from all upstream segments)
6. Pipe diameter of each segment
7. Slope of each segment
8. Full flow capacity of each segment
9. Minimum velocity calculated in accordance with **Section 3.2.3 – Minimum Slopes**
10. Maximum velocity calculated in accordance with **Section 3.2.5 – High Velocity Protection**
11. Depths and velocities at design flows for each line segment of the proposed sewer.

2.3 – Design Period

In general, sewer systems shall be designed for the estimated ultimate tributary population, except when considering parts of the system that can be readily increased in capacity. Similarly, consideration should be given to the maximum anticipated capacity of institutions, industrial parts, etc. (*TSSS 32*)

In the case where the planning horizon of the drainage area is greater than the expected useful life of the pipe (50 years), the planning horizon may be used as the design period with the approval of the Utility Department.

2.4 – Design Factors

In general, sewer extensions shall be allowed only if the existing receiving lines are capable of handling the additional flows. Sizing of facilities will be designed to accommodate future development as defined by the Sewer Master Plan. If information is not available from the Sewer Master Plan, the sanitary sewer system shall be designed to accommodate the maximum anticipated capacity of institutions, industrial parts, etc. based on current or anticipated zoning.

Computations should be presented, in a tabular form, to indicate depths and velocities at Design Flow for the different sizes and phases of sanitary sewers being proposed.
In determining the required capacities of sanitary sewers the following factors should be considered:

1. Maximum hourly sewage flow.
2. Additional maximum sewage or waste flow from industrial plants.
3. Ground water infiltration.
4. Topography of area.
5. Location of waste treatment plant.
6. Depth of excavation.
7. Pumping requirements.
8. Future sewer expansions

2.5 – Design Flow Requirements

2.5.1 – Design Flow Definitions and Equations

Sanitary sewer systems shall be designed based on *Design Flow*.

Design Day - A 24-hour period of the greatest average flows experienced during the life of the system. This would typically be seen once the basin for each sanitary sewer tributary area has been fully developed.

Design Flow (Q_{design}) – The greatest flow demand resulting from Average Daily Flow, Maximum Day Flow, Peak Hourly Flow, or Peak Instantaneous Flow multiplied by an appropriate peaking factor. This is normally developed by using an appropriate peaking factor with the average daily flow.

(Example: $Q_{design} = Q_{avg2} * (P_d)$.

Design Maximum Day Flow – The design maximum day flow is the largest volume of flow to be received during a continuous 24-hour period expressed as a volume per unit time.

Design Peak Instantaneous Flow – The design peak instantaneous flow is the instantaneous maximum flow rate to be received.

2.5.1.1 – Average Flows

Average Daily Flow (Design Day) (Q_{avg2}) – The average flows for the design day to be received for a continuous 12-month period for which a design day would occur expressed as a volume per unit time. The design average flow for facilities having critical seasonal high hydraulic loading periods (e.g., recreational areas, campuses, and industrial facilities) shall be based on the average of the daily volumes to be received during the seasonal period. When forecasting future development, match flows from the highest density zoning available to a tract of land. (*ASCE-MOP60 Sec. 3.1*)

2.5.1.2 – Maximum Flows

Design Peak Hourly Flow (Q_{max}) – Also known as Capacity Design Flow in *ASCE-MOP #60,* the design peak hourly flow is the largest volume of flow to be received during a one-hour period expressed as a volume per unit time. This is developed by using an appropriate peaking factor with the average daily flow unless other design data is available. (*ASCE-MOP60 Sec. 3.1*)

(Example: $Q_{max} = Q_{avg2} \times P_d$)

2.5.1.3 – Minimum Flows

Minimum flow calculations are for use with the tractive force method and do not need to be provided if the tractive force method is not being used. See **Section 3.2.3 – Minimum Slopes** for additional information.

Design Minimum Flow (Q_{min})

The largest 1-hour flow that occurs during the low-flow week of the design life of the sanitary sewer reach being evaluated. The low-flow week will often occur at the beginning of the design life. This flow is used for self-cleansing design using the tractive force model with the objective of transporting the sediment during low-flow periods. By using **Q_{min}** for tractive force analysis to set minimum slopes in sewer design, the potential for sulfide-related corrosion can be minimized. (*ASCE-MOP60 Sec. 3.1*)

(Example: $Q_{min} = Q_{avg1} \times P_L$)

Average Daily Flow (Low Flow Period) (Q_{avg1}) – The average of the daily volumes to be received for the low flow period in the pipe, usually when the pipe is first placed into service.
(*ASCE-MOP60 Sec. 3.1*)

2.5.1.4 – Peaking Factors

Peaking factor is the ratio of a maximum flow to the average flow of a given time period.

- **P_d (Design Day Peaking Factor)** – The peaking factor for design day flows represents peaking factor where the greatest average flows are encountered. Also represented as (**P_2**) in (*ASCE-MOP60 Sec. 3.1*)

- **P_L – (Low Flow Peaking Factor)** – The peaking factor for Low Flow is limited to the low flow period. Also represented as (**P_1**) in *ASCE-MOP60 Sec. 3.1*

  The equations below may be used to develop either peaking factor (**P_d** or **P_L**) for residential areas as long as population and other factors have been adequately accounted for and adjusted. Commercial or industrial areas peaking factors shall be based on the proposed development when available. When proposed development information is not available, design flows shall be developed in accordance with **Section 2.5.5 – Commercial and Industrial Design Flows**. Other peaking factors may be used if justified and approved by the Utility Department and Arkansas Department of Health.

  Eq. 2.4.1.5(a): *Peaking Factor (P_D or P_L) = $[(18+k^{0.5}) / (4+k^{0.5})]$* *(TSSS Figure 1)*

  Eq. 2.4.1.5(b): *Peaking Factor (P_D or P_L) = ($Q_{max\ (gal)}$) / ($Q_{avg\ (gal)}$)* *(TSSS Figure 1)*

  k = Population in Thousands (i.e. 1000 people would be **k** = 1)
  (Units: Gallons per Day)

2.5.2 – Forecasting

Forecasting future wastewater flows for a given area is a difficult task. Many references, including Ten States Standards for Wastewater (2014), encourage use of historical per capita wastewater flows and population trends. However, per capita wastewater flows for a given area may not accurately reflect wastewater flow in the area due to nonresidential land uses. (*ASCE-MOP60 Sec. 3.1*)

Specific development information is preferred when available to create a more accurate forecast and help reduce the risk of creating an over or under sized sewer system. If specific development criteria is unavailable, forecasting must be based on the worst case scenario based on zoning classifications of the sanitary sewer tributary area. See **Section 2.5.3 – Zoning Classifications**, **Section 2.5.4 – Residential Design Flows**, and **Section 2.5.5 – Industrial and Commercial Design Flows** for additional information.

2.5.3 – Zoning Classifications

Zoning District	Maximum Dwelling Units/Acre
Residential Estate Three	0.33
Residential Estate One	1
Single Family - Low Density	3
Single Family - Medium Density	4
Single Family - Medium/High Density	6.7
Single Family - High Density	8.7
Single Family - Row House and Zero Lot Line	17
Single Family - Zero Lot Line	8
Single Family - Duplex Low /Medium Density	4
Single Family - Duplex Medium / High Density	6.7
Single Family - Duplex High Density	8.7
Multi-Family - Low Density	10
Multi-Family - Medium Density	20
Multi-Family - High Density	30
Transitional (Single Family)	3
Transitional (Two-Family)	6
Residentential Mixed Density	30

**Referenced from City of Fort Smith Municiple Code (Section 27)*

2.5.4 – Residential Design Flows

New residential sewer systems shall be designed on the basis of an average daily per capita flow of 100 gallons per person per day. This figure is used in conjunction with a peaking factor detailed in **Section 2.5.1.4 – Peaking Factors** to cover normal infiltration. (*TSSS 11.243b*)

Single family homes shall be assumed to have an average of 3.5 people per dwelling unit. Multifamily shall be assumed to have an average of 4 people per 3-bedroom dwelling unit; 2.2 people per two bedroom dwelling unit and 1.7 people per one bedroom dwelling unit.

If specific development information is unavailable, the design engineer shall assume that all single family homes shall have three bedrooms, multi-family shall have two bedrooms. See **Section 2.5.3 – Zoning Classifications** to determine the number of dwelling units per acre based on zoning.

2.5.5 – Commercial and Industrial Design Flows

Commercial and industrial areas shall be designed using a minimum peak flow of 6000 gal./acre/day. Wherever heavier usages are anticipated, design shall be based on anticipated peak flows.

3. ALIGNMENTS AND PROFILES

3.1 – Sanitary Sewer Alignments

Sanitary sewers lines shall be designed with a straight alignment between manholes. Curvilinear alignment of sewers may be considered on a case-by-case basis provided compression joints are specified and ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves that start and end at manholes. When curvilinear sewers are proposed, the recommended minimum slopes indicated in **Section 3.2.3 – Minimum Slope** shall be increased accordingly to provide a minimum velocity of 2.0 feet per second when flowing full. *(TSSS 33.5)*

When possible, sanitary sewer lines alignment shall not be designed to run longitudinally under a road. When sanitary sewers are laid under roadways, manholes shall not be positioned in the wheel paths of normal vehicle travel.

3.2 – Sanitary Sewer Profiles

Sanitary sewers shall be designed with a uniform slope between manholes. All slope adjustments must occur at manhole locations (*TSSS 33.44*).

3.2.1 – Minimum Depth

The minimum cover over any sewer line shall be 24". (*TSS 33.2*) Special conditions or drawings must be included on the plans for embedment and compaction to provide adequate pipe support where sanitary sewer line depths may be less than 30-inches before or after construction. (*PVC – Section 12.4.7*) Sanitary sewers should be installed at such depths that they can receive contributed flows from the tributary area by gravity flow. Deep basements and buildings on land substantially below street level may require individual pumping facilities. Sufficient sanitary sewer depth must be provided to prevent freezing and backflow of wastewater through connections. (*ASCE-MOP60 Sec. 6.8*)

When designing sewer depths, it should be noted that the Arkansas plumbing code states that the most private sanitary sewer service lines are required to maintain a slope of approximately 1% (*APC Table 704.1 for additional information*). See **Section 7 – Sanitary Sewer Services** for additional information regarding public sanitary sewer service lines.

3.2.2 - Maximum Depth

When practical, sanitary sewer lines should not be designed to be more than 6-feet below finished grade to prevent easements with excessive width and allow for easier future maintenance. See **Section 8 - Easements** for additional information on how sanitary sewer depth affects easement widths. Additional consideration should be given to service line connections and the required depths and slopes in order for each service to connect. Pipes designed to be installed deeper than 15 feet deeper shall be accompanied by pipe deflection calculations. Additional design and construction requirements may be mandated by the Utility Department.

3.2.3 – Minimum Slopes

The pipe diameter and slope shall be selected to obtain the greatest practical velocities so as to minimize settling problems. Flatter slopes shall not be justified with oversize sewers. If the proposed slope is less than the minimum slope of the smallest pipe that can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer shall be calculated by the design engineer and be included with the plans. Any variance from the minimum design standard must have written approval from Arkansas Department of Health and the City of Fort Smith Utility Department. *(TSSS 33.43)*

3.2.3.1 – Minimum Slopes For Small Diameter Sewers (≤ 48" in Diameter)

All sanitary sewers smaller than 48 inches in diameter shall be so designed and constructed to give mean velocities of not less than 2.0 feet per second when flowing full based on Manning's formula using an "n" value of 0.013, regardless of pipe material type *(TSSS 33.41)*. Use of other practical "n" valves may be permitted during plan review if deemed justifiable based on research or field data presented. Any "n" value less than 0.013 must be approved in writing by both the Arkansas Department of Health and the City of Fort Smith.

See **Table 3.2.3.1 – Minimum Sanitary Sewer Slopes** for the minimum slopes for each size of pipe based on the use of a Manning's "n" value of 0.013. Slopes greater than the slopes listed in **Table 3.2.3.1** are desirable to allow for tolerances during construction, to control sewer gases, and to maintain self-cleansing velocities at all rates of flow within the design limits.

(Table 3.2.3.1)

Minimum Sanitary Sewer Slopes

Sewer Diameter	Minimum Change in Elevation	
(in.)	(ft / 100 ft)	Slope (%)
6	0.50'	0.50%
8	0.40'	0.40%
10	0.28'	0.28%
12	0.22'	0.22%
14	0.17'	0.17%
15	0.15'	0.15%
16	0.14'	0.14%
18	0.12'	0.12%
21	0.10'	0.10%
24	0.08'	0.08%
27	0.067'	0.067%
30	0.058'	0.058%
36	0.046'	0.046%
42	0.037'	0.037%

Source: TSSS - 33.41

ASCE and Water Environment Federation (WEF) now advocate a transition to the tractive force approach for self-cleaning sanitary sewer designs. The design engineer may utilize the "*Procedure for Calculating Minimum Sewer Slope Using Tractive Force Design for Self-Cleansing*" (*ASCE-MOP60*) when calculating slopes less than those listed in the **Table 3.2.3.1 – Minimum Sanitary Sewer Slopes**. Any design utilizing the tractive force method may be approved after review from the City of Fort Smith Utility Department and Arkansas Department of Health.

3.2.3.2 – Minimum Slopes For Large Diameter Sewers (≥ 48" in Diameter)
Sewers 48" or larger should be designed and constructed to give mean velocities when flowing full of not less than 3.0 feet per second, based on Manning's formula using an "n" value of 0.013. *(TSSS 33.41)*

3.2.4 – Minimum Flow Depths

Slopes that are slightly less than the recommended minimum slopes may be permitted. Such decreased slopes may be considered where the depth of flow will be 0.3 of the diameter or greater for the design average flow. Any variance from the minimum standard must have written approval from the City of Fort Smith Utility Department. *(TSSS 33.42)*

3.2.5 - High Velocity Protection

All sanitary sewers shall be designed and constructed to give mean velocities not greater than 10 feet per second when flowing full based on Manning's formula. When calculating fluid velocity to determine the need for high velocity protection, the engineer shall use the lowest Manning's "n" value for the actual material selected. For example the PVC Pipe Association recommends the use of a Manning's "n" value = 0.009 for PVC (*PVC – Section 9.4*). Where velocities greater than 10 feet per second are attained, special provision shall be made to protect against displacement by erosion and shock (*TSSS 33.45*). See **Table 3.2.5 – Manning's Roughness Coefficient Values for High Velocity Calculations** for Manning's "n" values that may be used when determining the need for high velocity protection.

(Table 3.2.5) Manning's Roughness Coefficient Values for High Velocity Calculations	
Material Type	**Roughness Coefficient "n"**
Concrete	0.010
Ductile Iron	0.011
HDPE	0.010
PVC	0.009
Steel	0.011
Vitrified Clay	0.013

3.2.6 – Anchoring Systems Required

Sewers on 20% slope or greater shall be anchored securely with concrete anchors or equal, spaced as follows (*TSSS 33.46*) (*PVC – Section 12.4.9*):

a. Not over 36 feet center to center on grades 20% and up to 35%.

b. Not over 24 feet center to center on grades 35% and up to 50%.

c. Not over 16 feet center to center on grades 50% and over.

3.2.7 – Design Velocities

Sanitary sewers must be designed in such a way to give a minimum velocity of 2.0 feet per second (or as required by the tractive force method) and a maximum velocity of 10 feet per second during full flow scenarios. Additional details related to design velocity can be found in **Section 3.2.3 – Minimum Slopes** and **Section 3.2.5 – High Velocity Protection**. *(TSSS 33.41 & 33.45)*

4. DETAILS OF DESIGN

4.1 – Sanitary Sewer System Layout

Consideration should be given to future needs. The sanitary sewer system should be designed to serve not only the present tributary area but also shall be compatible with an overall master plan as determined by the Utility Department. Sanitary sewer lines shall be extended across property frontages to allow for future development when future development is possible as determined by the Utility Department.

4.2 –Pipe Sizes

4.2.1 – Minimum Sanitary Sewer Pipe Size

No sewer shall be less than 8 inches in diameter, except for isolated areas where no expansion is possible. In these areas, 6 inches lines may be used with design flow less than 50% of capacity and with written approval from the Utility Department. *(TSSS 33.1)*

4.2.2 – Changes in Pipe Sizes

All changes in pipe size shall occur at manholes. When a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

Sewer extensions should be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole. However, special consideration shall be given to an appropriate flow channel to minimize turbulence when there is a change in sewer size. The Utility Department may require a schedule for construction of future downstream sewer relief. (*TSSS 33.6*).

4.3 – Materials

4.3.1 – Material Conformance

All materials including pipe, manholes, couplings, and other appurtenances shall conform to the latest revision of the City of Fort Smith Standard Specifications and Arkansas Department of Health (ADH) and Arkansas Department of Environmental Quality (ADEQ). Any materials not conforming to the referenced specifications may be considered on a case by case basis.

4.3.2 – Integrity of Sanitary Sewer Network

Pipes shall have sufficient structural strength and shall be properly supported and reinforced where necessary to guard against structural failures and resulting sanitary hazards. *(ADH-APWS XIV)*

Pipe shall be selected based on the following considerations:

1. Material Yield Strength
2. Trench Load
3. Deflection
4. Casting Allowance
5. Geotechnical and Environmental Conditions

*(Additional Depth requirements are discussed in **Section 3.2 – Sanitary Sewer Profiles**)*

4.3.3 – Tracer Wire

All sanitary sewer lines must have tracer wire installed to meet the requirements of the State of Arkansas. *(A.C.A. 14-271-111)*

All tracer wires must terminate in a tracer wire box. Tracer wire boxes shall be located on design plans at intervals not exceeding 500 feet. Design plans shall show a tracer wire box to be located within five feet of every manhole. If any additional tracer wire boxes are needed due to interval spacing requirements, tracer wire boxes shall be located near other sanitary sewer appurtenances. If no sanitary sewer appurtenances are nearby, tracer wire boxes shall be located near street intersections or other easily accessible area.

4.4 – Geotechnical Considerations

4.4.1 - Corrosive Soil Environments

Protection from corrosive soil environments must be considered when proposed sanitary sewer line is to be located in areas found to have corrosive soils. Sanitary sewer line protective wraps and coatings must be designed in accordance with City of Fort Smith Standard Specifications and the latest revisions of the applicable AWWA standards. Ductile iron pipe, fittings, and appurtenances shall be encapsulated with polyethylene. Corrosion surveys shall be performed in accordance with the latest requirements from *AWWA M11*, *AWWA M41*, or *DIPRA DDM*. The Utility Department may require additional protection or testing during review.

Appropriate measures should be taken to protect the valves, bolts, nuts, and other appurtenances against corrosion. These items shall be encapsulated with polyethylene wrapping unless approved by the Utility Department. *(AWWA M44 – Chapter 2)*

4.4.2 – Geotextile Encapsulation

All sanitary sewer lines located within the 100-year flood plain or areas with significant groundwater flow must be designed so that the entire pipe zone will be enveloped by a non-woven geotextile (filter fabric) to prevent soil migration and to ensure adequate soil support.

4.4.3 – Protection From Superimposed Loads

All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of trench. Where necessary, special bedding, haunching and initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated superimposed loading or loss of trench wall stability. See ASTM D-2321 or ASTM C-12 as appropriate. (*TSSS 33.7*)

In rigid sewer pipes the inherent strength of the pipe is the predominant source of it's supporting ability; however, in plastic pipes, the supporting ability is derived from soil used in the embedment and backfill. Therefore, the use of plastic sewer pipe shall be considered only when proper design of the pipe and it's embedment has been presented. (*ADH-PVCS*)

4.4.4 – Buoyancy

Buoyancy of sewers shall be considered. Floatation of the pipe shall be prevented with appropriate construction where high groundwater conditions are anticipated. (*TSS 33.3*)

4.4.5 – Permeation (Petroleum Products & Organic Solvents)

Documented research has shown that pipe materials (such as polyethylene and polyvinyl chloride) and elastomers, such as those used in jointing gaskets and packing glands, are subject to permeation by low-molecular-weight organic solvents or petroleum products. If a sanitary sewer line must be installed in such a contaminated area or an area subject to contamination, the design engineer must consult with material manufacturer regarding permeation and provide the manufacture's recommendation to the Utility Department for review. *(AWWA C111)*

The Arkansas Department of Health has stated that PVC pipe should not be installed where soils are or will be exposed to solvents, gasoline, petroleum products, etc *(ADH-PVCW).* The City of Fort Smith Utility Department is applying the same guidance to all sanitary sewer designs.

Consideration must also be given to the type of gaskets being used in areas that are or will be exposed to similar soil contaminations. This consideration must be given to all gaskets regardless of pipe type.

4.5 – Sanitary Sewer Line Encasement

4.5.1 - Encasement Details

Sanitary sewer lines shall be encased when crossing roadways, railroads, and streams. When possible, casings will be installed with a minimum depth of 36-inches below the bottom of the ditch line or native ground, or 42-inches below the top of the roadway subgrade, whichever gives the greatest cover. Casings may be required to be placed deeper based on permitting requirements or as engineering judgement may require. Casings must be designed and installed in accordance with the latest revision of the City of Fort Smith Standard Specification and as required by any permitting agency.

Casings shall, as a minimum, extend six feet beyond the flow line of the parallel ditches; toe of slope, or back of curb as applicable for the roadway section.

Casings must be designed to accommodate approved spacers and joint restraint. The casing diameter shall be a minimum of two times the diameter of the carrier pipe unless otherwise approved in writing by the Utility Department.

4.5.2 - Locations Requiring Encasement

Sanitary Sewer Lines must be bored and encased in the following locations:

1. Railroad crossings in accordance with approved railroad permit.
2. Stream crossings. Boring requirement may be waived based on approved permits.
3. ArDOT maintained roadways in accordance with approved ArDOT permit.
4. All public roadway crossings.

    Exception to Public Roadway Crossings:

    a. Sewer lines under a "Residential Street" as classified by the City of Fort Smith Master Street Plan with a surface older than two years or prior to roadway construction may be installed by an open cut method without the need to be encased. Encasement is still required when bored.

5. Sanitary Sewer Service Line Crossings (See **Section 7 – Sanitary Sewer Services** for additional details)
6. Areas of Possible Cross Connection (See **Section 5 – Sanitary Sewer Proximity To Other Features** for additional details)

5. SANITARY SEWER PROXIMITY TO OTHER FEATURES

5.1 – Sanitary Sewers in Relation to Potable Water Systems

5.1.1 – Cross Connections

Any physical connection is prohibited whereby a public water system whether community or non-community, is connected to an unsafe or questionable water supply system either inside or outside of any building or buildings. (*ADH-APWS XVI*)

There must be no physical connection between any water supply system and any storm or sanitary sewer system, or any appurtenance, thereto which would permit the passage of polluted water into the potable supply. (*TSSS 38.1*)

Every precaution must be taken against the possibility of sewage contamination of the water in the distribution system. Water mains and sanitary sewers must be constructed as far apart as practicable, and must be separated by undisturbed and compacted earth. (*ADH-APWS XIV*)

See the City of Fort Smith Ordinances for additional information regarding the City of Fort Smith Cross Connection Control Program. (*CFS 25-166*)

5.1.2 – Horizontal Separation

Water mains and sanitary sewers shall be constructed as far apart as practical, and shall be separated by undisturbed and compacted earth. A minimum horizontal distance of ten feet should be maintained between water lines and sewer lines or other sources of contamination. Water lines and sewers must not be laid in the same trench except on the written approval of the Arkansas Department of Health and the City of Fort Smith Utility Department. (*ADH-APWS XIV*)

No potable water pipe shall pass through or come into contact with any part of a sewer manhole. (*TSSS 38.1*) Fire hydrant drains shall not be connected to or located within 10 feet of sanitary sewers, storm sewers, or storm drains. (*TSSW – 8.4.4*)

5.1.3 – Vertical Separation and Crossing

Water mains necessarily in close proximity to sewers must be placed so that the bottom of the water line will be at least 18 inches above the top of the sewer line at its highest point. If this distance must unavoidably be reduced, the water line or the sewer line must be encased in watertight pipe with sealed watertight ends extending at least 10 feet either side of the crossing. Any joint in the encasement pipe is to be mechanically restrained. The encasement pipe may be vented to the surface if carrying water or sewer under pressure. Where a water line must unavoidably pass beneath the sewer line, at least 18 inches of separation must be maintained between the outside of the two pipes in addition to the preceding encasement requirement. Exceptions to this must be approved in writing by the Arkansas Department of Health and the City of Fort Smith Utility Department. (*ADH-APWS XIV*)

5.2 – Sewers In Relation To Streams

5.2.1 – Cover Depth In Relation to Streams

The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line. In general, the following cover requirements shall be met:

a. One foot of cover where the sewer is located in rock;
b. Three feet of cover in other material. In major streams, more than 3 feet of cover may be required; and
c. In paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement.

Less cover may be approved only if the proposed sewer crossing will not interfere with future modifications to the stream channel. Justification for requesting less cover shall be provided to the reviewing authority. (*TSSS 36.11*)

5.2.2 – Horizontal Location In Relation to Streams

Sewers located along streams shall be located outside of the stream bed and at a sufficient distance to provide for future possible stream widening and to prevent pollution by siltation during construction. (*TSSS 36.12*)

5.2.3 – Structures In Relation to Streams

The sewer outfalls, headwalls, manholes, gate boxes, or other structures shall be located so they do not interfere with the free discharge of flood flows of the stream. (*TSSS 36.13*)

5.2.4 – Alignment In Relation to Streams

Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade. Sewer systems shall be designed to minimize the number of stream crossings. (*TSSS 36.14*)

5.2.5 – Materials In Relation to Streams

Sewers entering or crossing streams shall be designed using ductile iron pipe with mechanical joints; otherwise they shall be designed so they will remain watertight and free from changes in alignment or grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials which will not readily erode, cause siltation, damage the pipe during placement, or corrode the pipe. (*TSSS 36.21*)

5.2.6 – Siltation and Erosion In Relation to Streams

Construction methods that will minimize siltation and erosion shall be employed. The design engineer shall include in the project specifications the method(s) to be employed in the construction of sewers in or near streams. Such methods shall provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting trees and vegetation, dumping of soil or debris, or pumping silt-laden water into the stream. Specifications shall require that cleanup, grading, seeding, planting and/or restoration of all work areas shall begin immediately. Exposed areas shall not remain unprotected for more than seven days. (*TSSS 36.22*)

5.2.7 – Aerial Crossings In Relation to Streams

Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning, and settlement. Precautions against freezing, such as insulation and increased slope, shall be provided. 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 frost heaving. For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the 50 year flood. (*TSSS 36.23*) Long span pipe shall be utilized where practical to limit the number of support structures.

6. MANHOLES

6.1 Location of Manholes

Manholes shall be located at the junctions of sanitary sewers and at any change in grade, pipe size, or alignment, except in curved alignments and at the end of each line segment. Also, manholes should be placed at locations that provide ready access to the sewer for preventive maintenance and emergency service. (*ASCE-MOP60 – Section 6.4*) (*TSSS 34.1*)

Manholes shall not be located in any low area, such as a swale or gutter, where there will be a concentrated flow of water over the top that could cause excessive inflow. Inaccessible manholes are of little or no value and should be avoided when possible. If manholes must be constructed in these areas, careful attention must be paid to design to ensure that the manholes are watertight and protected against flotation. (*ASCE-MOP60 – Section 6.4*)

Street intersections are common locations for manholes. When a manhole is not necessary for a present or future junction, it is better placed outside the pavement of a street intersection, but within the street ROW or adjacent utility easement, to minimize issues during potential future road repairs and to provide room for maintenance personnel. A terminal manhole at the upper end of a sanitary sewer should be placed in the street ROW or adjacent utility easement so that the manhole and sewer are accessible for maintenance and emergency service. Unless a sufficient access easement is available, it should not be located inside the property line of the last property served. Thus, for proper location of the terminal manhole, the sewer may need to be extended to the street ROW or adjacent utility easement as necessary. (*ASCE-MOP60 – Section 6.4*)

6.2 – Manhole Spacing

Manholes shall be spaced at distances not greater than 400 feet for sewers 15 inches or less, and 500 feet for sewers 18 to 30 inches. Greater distances may be acceptable, if approved by the Utility Department. In any situation, it is very important to consult with the utility's operational staff to ensure that the design provides proper access for system maintenance.

(Table 6.2)

Maximum Spacing Between Manholes

Pipe Diameter	Maximum Spacing
15" and Less	400'
18" to 30"	500'
Greater than 48"	600' *

**With Utility Department Approval*

6.3 – Drop Manholes

A drop pipe shall be provided where the flow line elevation of an incoming sewer line is 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition. (*TSSS 34.2*)

Drop manholes should be constructed with an outside drop connection. Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete.

Inside drop connections may be allowed with special approval from the Utility Department. Inside drop manholes will only be allowed in manholes with an inside diameter of 48-inches or greater with the interior drop pipe being secured to the interior wall of the manhole and shall provide access for cleaning. (*TSSS 34.2*)

6.4 – Manhole Diameter

The minimum diameter of manholes shall be either 48 inches or 1 ½ times pipe diameter, whichever is larger. A minimum access diameter of 24 inches shall be provided.

6.5 – Manhole Flow Channel

The flow channel straight through a manhole should be made to conform as closely as possible in shape and slope to that of the connecting sewers. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not obstruct maintenance, inspection, or flow in the sewers. Changes in grade or alignment shall be made smoothly with as large a transition as possible. When curved flow channels are specified in manholes, including branch inlets, the minimum slopes indicated in **Section 3.2.3 – Minimum Slopes** should be increased to maintain acceptable velocities. (TSSS 33.41)

6.6 – Bench

A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than ½ inch per foot (4 percent). No lateral sewer, service connection, or drop manhole pipe shall discharge onto the surface of the bench. (*TSSS 34.5*)

6.7 – Water Tightness

Sanitary sewer manholes should not be located or designed in a way that allows surface water to enter. When this is not possible, a hinged watertight camlock manhole covers shall be specified. Interior liners can be either nonmetallic or metallic, with metallic liners preferable in high-traffic areas. Manholes not in the pavement, especially in open country, should have their rims set above grade to avoid the inflow of stormwater and to simplify field location. (*ASCE-MOP60 – Section 6.4*)

Manholes shall be of the pre-cast concrete (as prescribed by ASTM C-478) or poured-in-place concrete type. Manhole lift holes and grade adjustment rings shall be sealed with non-shrinking mortar or other material approved by the Utility Department.

Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or another watertight connection that is approved by the Utility Department that allows differential settlement of the pipe and manhole wall to take place.

In all areas where manhole covers are subject to inundation and high water or runoff from storms, the manholes shall have watertight or sealed manhole covers installed or be raised to an elevation above the 100-year flood elevation. Locked manhole covers may be desirable in isolated easement locations or where vandalism may be a problem. (*TSSS 34.6*)

6.8 – Corrosion Protection for Manholes

Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection on the interior of the manholes shall be provided. (*TSSS 34.8*)

6.9 – Electrical

Electrical equipment installed or used in manholes shall conform to Paragraph 42.35 of the 2014 edition of the Ten States Standards.

6.10 – Inverted Siphons

Inverted siphons must have special approval from the Utility Department and shall have not less than two barrels, with a minimum pipe size of 6 inches. They shall be provided with necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures shall also have adequate clearances for cleaning equipment, inspection, and flushing. Design shall provide sufficient head and appropriate pipe sizes to secure velocities of at least 3.0 feet per second for design average flows. The inlet and outlet details shall be so arranged that the design average flow is diverted to one barrel, and so that either barrel may be removed from service for cleaning. The vertical alignment should permit cleaning and maintenance. (*TSSS 35*)

7. SANITARY SEWER SERVICES

7.1 – Sanitary Sewer Service Connection Limitations

Except as approved by the Arkansas Department of Health and the City of Fort Smith, in no case shall a residential building be allowed to connect to the same water, building drain or building sewer service of another private residential building. (*APC 603.2.3*) (*CFS 25-185d*)

Sanitary sewer service lines greater than 4-inches must connect at manholes. Service lines 4 inches and below may connect with a wye connection to a sanitary sewer line.

7.2 – Service Cleanout Requirement

New sanitary services shall have a cleanout located at the property line, utility easement line, or ROW line to delineate where private service line ends and public service line begins. (*CFS 25-69*).

7.3 – New Sanitary Sewer Service Connections

All new sanitary sewer service lines shall be installed from the main to the property line or edge of easement and terminate with a service cleanout. All sanitary sewer services shall be installed at the time of the sanitary sewer main construction for all lots being served. Sanitary sewer service lines shall be installed prior to any roadway work in new construction where sanitary sewer service lines will cross. The utility owned portion of sanitary sewer service lines shall be designed with a uniform slope with a minimum slope of 2% for 4-inch lines and a slope of 1% for 6-inch and greater lines unless otherwise approved by the utility department. Where the depth of the sewer main is greater than 8-feet, a riser shall be utilized. All service stub outs shall be capped or plugged and marked with a nylon rope.

7.4 – Connection to Public Sewer Required

Connection to a public sewer system is required of all homes and businesses when the point where sewer exits the building is located within 300 feet of access to the public sewer located on the owner's property or an adjacent street or alley (*CFS 25-183 (d), A.C.A. 14-235-304, & ADH Section VII*).

8. EASEMENTS

8.1 – Easements for Sewer Lines and Appurtenances

All sewer lines not located in a public right-of-way shall be located in a sewer easement with a width no less than 15 feet wide or a width 2.5 times the depth of the line, whichever is greater. Greater widths may be required due to the size of line or to accommodate appurtenances. Any exceptions must be approved by the Utility Department in writing. Easements that run parallel to a property line must not straddle said property line but instead be located wholly on one property.

Where alleys are not provided, adequate easements shall be provided where necessary for use by utilities. Utility easements shall be separated from drainage easements except for necessary crossings. (*CFS 27-504-1A*)

All water and sewer easements shall be of such dimensions as to provide access for the construction, and maintenance of the facilities within the easements and according to the applicable design standard. (*CFS 27-504-1B*)

All easements acquired, developed through platting, or used by the project shall have easement type and dimensions detailed on plan set. The recorded book and page or recorded plat location shall be detailed on record plan set.

8.2 – Easements and Landscaping

All landscaping located within any easement containing a water or sanitary line must be installed in accordance with the latest revision of the Utility Landscaping Development Policy.

No trees other than those in the small tree category on the recommended trees list may be planted under or within ten lateral feet of any overhead utility wire, or over or within five lateral feet of any underground water line, sewer line, transmission line or other utility in city parks, public grounds, or public rights-of-way on city park property. (*CFS 18-154-b.9*)

9. PRIVATE DEVELOPMENTS

The following options were created to address the development of large residential complexes, neighborhoods, and new developments requiring public water and sewer access on private property. The Utility Department reserves the right to individually review new developments and specify requirements that protect the integrity and operation of the public infrastructure as required beyond the scope of this document.

9.1 – General Requirements for Private Developments

The following requirements shall be met for all developments, regardless of whether the utilities are public or private beyond the property line:

1. All water taps to a public main must be performed by city personnel or designated representative.
2. All domestic and irrigation water connections to a public water main will be metered.
3. Water lines and sub-meters downstream of any public meter(s) shall be privately owned and maintained.
4. Sewer connections to public main shall be minimized. The number of sewer connections to public mains shall be justified by demonstration of slope calculations and engineering drawings.
5. All water and sewer utilities will be designed and constructed to current utility department standards.
6. Any water meters that services a fire hydrant, fire suppression system, or equivalent must have a fire rated meter installed.
7. Irrigation and fire lines shall comply with all requirements within the City of Fort Smith requirements, including the Cross Connection Control Program.
8. All other applicable AWWA Standards, City requirements, and State requirements must be met.

9.2 - Private Utilities with Private Access

1. All meters and sanitary sewer clean-outs shall be located at a point immediately outside of the private access area and within a utility easement or public Right-of-Way (ROW).
2. If an irrigation line, fire line, or fire hydrant are to be connected to a private domestic water line, a backflow prevention device shall be installed immediately beyond the public easement or ROW, in accordance with the City of Fort Smith Cross Connection Control Program.
3. If two water service lines are required, both water service taps shall have separate meters and backflow prevention devices in accordance with the City of Fort Smith Cross Connection Control Program.
4. Fire Hydrant locations must be designed and installed in accordance with the City of Fort Smith minimum design standards and standard specifications.
5. Fire Hydrants shall be privately owned and maintained. All private fire hydrants must have an approved permit from the City of Fort Smith, in accordance with the City of Fort Smith Cross Connection Control Program.

9.3 - Public Utilities with Private Access

1. The City of Fort Smith Utility Department must be able to access public facilities at all times (i.e. a gate code).
2. Access easement for private roadway must meet requirements set forth in Section 27-504 of the City of Fort Smith Municipal code.
3. Access easement shall have one access point connecting to a public ROW that shall be a minimum of 12 ft. wide to allow for heavy equipment access.
4. Sewer easements width shall be at least 2.5 feet for every 1 foot of pipe depth. A minimum of 15 foot width with the sewer line centered within the easement. Additional easement width may be required.
5. Water easements shall be a minimum of 15 foot width with the water line centered within the easement. Additional easement width may be required.
6. Water and Sewer Easements shall be exclusive.
7. All crossings under private roadway shall be considered private.
8. Fire Hydrants shall be public.
9. Fire Hydrants shall follow City spacing specifications.
10. Irrigation lines and fire lines shall have separate taps on the public main, and shall not be connected to domestic water service lines.
11. No permanent structures will be allowed within the water or sanitary sewer easements.

10. PLANS & SPECIFICATIONS

10.1 – Plan Specifications

All designs, plan and specifications submitted to the City for approval for the construction of public utility infrastructures (water and sewer) shall be prepared by a registered professional engineer, licensed in the State of Arkansas. All design and construction techniques shall conform to the City of Fort Smith's Standard Specifications. Any changes or special details will need to be specifically approved by the City of Fort Smith Utility Department.

10.2 – Plan Set Requirements

All plan sets that propose work in connection with the water or sewer infrastructure shall have the following items detailed:

A. All easements acquired, developed through platting, or existing easements that are used by the project shall have easement type and dimensions detailed on plan set.

B. Water lines and sewer lines shall be shown in both in a plan view and a profile view. Material, size, elevations (flow line, existing grade, and finished grade), slopes of each pipe segment, and any appurtenances shall be shown in their proper views. All elevations shall be based upon USGS datum with location of benchmark given.

C. All coordinates used on plans and specifications shall be based on the City of Fort Smith coordinate system.

D. All connections, bends, junctions, and manholes shall be coordinately located on the plan set.

E. A project location sheet shall be provided which details the project location in relation to streets, subdivisions, governing boundary lines, any major geographical features such as streams or bodies of water, and the 100-year flood plain elevation line.

F. Information such as geotechnical data, environmental data, information on other utilities, or special construction requirements may be required in addition to the previous requirements.

10.3 – Record Drawing Requirements

All public water and sewer improvements shall not be accepted by the City of Fort Smith Utility Department until record drawings have been received and reviewed by the Utility Department. Record drawings shall contain updated information for the items detailed in **Section 10.2 – Plan Set Requirements** and based on actual results of construction. All easements acquired, developed through platting, or existing easements used by the project shall have easement type, dimensions, and the recorded book and page or recorded plat location detailed on plan set. Record plan set shall not be sealed by an engineer.

11. REFERENCED STANDARDS

1. **A.C.A. – Arkansas Code Annotated**
    a. A.C.A. § 14-56-413 – *Territorial Jurisdiction*
    b. A.C.A. § 14-271-111 (a) (2) – *Underground Facilities Damage Prevention*
    c. A.C.A. § 14-234-105 – *Alteration Despite Zoning Regulations*
    d. A.C.A. § 14-235 – *Municipal Sewage Systems*
    e. A.C.A. § 17-30 – *Engineers*
    f. A.C.A. § 20-7-109 – *Authority to Regulate Public Health (Board of Health)*

2. **ADH – Arkansas Department of Health**
    a. ADH-APWS – *Arkansas State Board of Health – Rules and Regulations Pertaining to Public Water Systems (02/24/2014)*
    b. ADH-GS – *Arkansas State Board of Health – Rules Pertaining To General Sanitation*
        i. Section VII (c)
    c. ADH-PVCS – *Arkansas Department of Health – Policy on Plastic Pipe for Public Sewer Systems (October 2008)*
    d. ADH-PVCW – *Arkansas Department of Health – Policy Statement: PVC Pipe for Use In Public Water Systems (October 2008)*

3. **APBSP - Arkansas Standards of Practice For Property Boundary Surveys and Plats (05/21/2009)**

4. **APC – Arkansas Plumbing Code - (2006)**
    a. Section 603.2.3 – *Individual Water*
    b. Section 704.1 – *Drainage Piping Installation*

5. **ASCE – American Society of Civil Engineers**
    a. MOP60 – *Manual of Practice #60 (2nd Edition) (aka: WEF MOP #FD5) – Gravity Sanitary Sewer Design and Construction*

6. **ASTM – ASTM International (*formerly known as American Society for Testing and Materials*)**
    a. ASTM C-12 – *Standard Practice for Installing Vitrified Clay Pipe Lines*
    b. ASTM C-478 – *Standard Specification for Circular Precast Reinforced Concrete Manhole Sections*
    c. ASTM D-2321 – *Standard Practice For Underground Installation Of Thermoplastic Pipe For Sewers And Other Gravity Flow Applications*

7. **AWWA – American Water Works Association**
    a. C111 – *Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*
    b. C600 – *Installation of Ductile-Iron Mains and Their Appurtenances*
    c. M11 – *Steel Pipe – A Guide for Design and Installation (5th Edition)*
    d. M23 – *PVC Pipe – Design and Installation (2nd Edition)*
    e. M41 – *Ductile-Iron Pipe and Fittings (3rd Edition)*
    f. M44 – *Distribution Valves: Selection, Installation, Testing, and Maintenance(3rd Edition)*
    g. M51 – *Air Valves: Air-Release, Air/Vacuum & Combination (2nd Edition)*

8. ADEQ – Arkansas Department of Environmental Quality

9. CFS – City of Fort Smith Municipal Code of Ordinances

a. Section: 6-238 – *Code Adopted (Fully Adopts APC)*
b. Section: 18-154 – *Tree Planting, Planting, Maintenance And Removal*
c. Section: 25-69 – *Sanitary Sewer System Connections*
d. Section: 25-166-176 – *Cross Connection Control Program*
e. Section: 25-183 (d) – *Use of Public Sewers Required*
f. Section: 25-185 – *Building Sewers and Connections*
g. Section: 25-193 – *Extension of Lines*
h. Section: 27-504-1 – *Utility Easements*
i. Section: 27-505 – *Sanitary Sewer*

10. DIPRA – Ductile Iron Pipe Research Association

a. DIPRA-CML - *Cement-Mortar Linings for Ductile Iron Pipe (March 2017)*
b. DIPRA-DDM – *Design Decision Model (DIPRA & Corrpro) (May 2018)*
c. DIPRA-CCPE – *Corrosion Control Polyethylene Encasement (January 2017)*

11. PVC – PVC Pipe Association – Hand Book of PVC Pipe Design and Construction (5th Edition)

a. Section 9.4 – *Flow in PVC Non-Pressure Pipe*
b. Section 12.4.7 – *Embedment Compaction*
c. Section 12.4.9 – *Sewers on Steep Slopes*

12. TSSS– Ten States Standards - Sewer

13. TSSW – Ten States Standards – Water