DESIGN STANDARDS

SECTION DS 6

SANITARY SEWER SYSTEM

DS 6-01 GENERAL:

A. INTENT: The intent of these Design Standards is to provide minimum standards for the design of a wastewater system that will dependably and safely collect wastewater from throughout the City and convey it to the wastewater treatment plant.

B. GOVERNING CRITERIA: These Design Standards, in conjunction with the most current edition of the City of Vacaville Sanitary Sewer Master Plan, hereafter referred to as Sewer Master Plan, shall govern the engineering design of all sanitary sewer system improvements within the City of Vacaville. In the event that there is a conflict with the criteria between these two documents or with other “Current Standards” so defined hereafter, the Director of Public Works shall determine which document governs. Additionally, if there are criteria or issues not addressed in these documents the Director of Public Works will determine the criteria to be used in the design.

C. CURRENT STANDARDS: Sanitary sewer design shall be completed in accordance with all current applicable laws, standards, and regulations including but not limited to the California Plumbing Code, American Society For Testing and Materials (ASTM), American Water Works Association (AWWA), California Department of Health Services, and the City of Vacaville: Sewer Master Plan, Municipal Code, and City Standard Specifications which include the Design Standards, Construction Standards and the Standard Drawings.

D. SEWER SYSTEM MASTER PLANNING: Sanitary sewer flows for planning purposes shall be estimated using the criteria included in the Sewer Master Plan. The City of Vacaville, Department of Public Works is responsible for all master planning of the sanitary sewer system. The design flow for Trunk Sewers (12 inch diameter and larger) is determined by Public Works Utilities Division through periodic master planning. Refer to the most current edition of the Sewer Master Plan for applicable design flows. At the discretion of the Director of Public Works, or in the absence of a current Sewer Master Plan, a special study shall be conducted to determine revised design flows, especially where Trunk Sewer alignments or land use assumptions for the development area are substantively different from the Sewer Master Plan. The special study shall be performed by the Department of Public Works or its consultant and shall be paid for by the developer. The special study shall include an analysis of the existing downstream sewer system and any phasing of the proposed project to identify any and all impacts of the proposed development on the existing City system. The analysis shall include recommendations for improvements to mitigate these impacts.
E. DESIGN REQUIREMENTS FOR ADDITIONS TO THE SANITARY SEWER SYSTEM: Additions to the sanitary sewer system shall be contingent on submission of a layout of all proposed sewer facilities and hydraulic calculations which satisfy all the design criteria outlined in these Design Standards. The calculations shall include a node map that depicts the entire area to be served by the subject sewers. For each sewer segment, the calculations shall include the basis of the design flow, pipe diameter, pipe length, inverts, slope, gravity flow capacity flowing full, allowable flow, and percent of the full-pipe capacity used at the design flow. City approval of the proposed design includes approval of the design assumptions and calculations to ensure that new Collection Main system improvements are consistent with system master planning and are properly sized to accommodate all planned flows, including proposed and future growth.

F. CATEGORIES OF SANITARY SEWER SYSTEM PIPING: There are four categories of sanitary sewer system piping included in the public system which is owned and maintained by the City of Vacaville as follows:

1. Service Lateral: piping connecting the sewer Collection Main system to the clean out or manhole at the private property line.

2. Collection Main or Main: piping solely located within the public right-of-way or easement connecting the Service Lateral to the Trunk Sewer.

3. Trunk Sewer: Larger diameter mains solely located within the public right-of-way or easement that deliver flow to the wastewater treatment plant, and generally serve more than one development area.

4. Force Main: Pressure piping solely located within the public right-of-way or easement that delivers flow from a Lift Station to the first downstream Gravity Main or Trunk Sewer at a manhole.

DS 6-02 SYSTEM DESIGN:

A. PIPE SIZING REQUIREMENTS: Pipe sizing in the Trunk Sewer and Collection Main sanitary sewer system shall be based on anticipated Design Flow at buildout for the service area and the hydraulic characteristics of the piping system as required by these Design Standards. The service lateral size shall be based upon the most current edition of the Plumbing Code enforced by the City of Vacaville; however the minimum size shall not be less than four (4) inches in diameter for residential services and six (6) inches for commercial or industrial services.

The City may require the developer to over size the Collection Main or Trunk Sewer beyond both the size required to serve the development and the City minimum size.
The following sizes are allowed in the City Sanitary Sewer system:

1. **Service Lateral** – 4 inch and larger. See Section DS 6.03B, “Sanitary Sewer Appurtenances, Services” of these Design Standards.

2. **Collection Main** - 8 & 10 inch

3. **Trunk Sewer** - 12 inch and larger

**B. DESIGN FLOW:** Design flow \((Q_d)\) is defined as peak wet weather flow at buildout for the service area. \(Q_d\) is calculated by summing the peak dry weather flow \((Q_{pdwf})\) and infiltration and inflow \((I)\).

The design flow for a Trunk Sewer is determined by the Department of Public Works using the City’s sewer computer model through master planning or special study per Section DS 6-01 D of these Design Standards.

The design flow for a Collection Main shall be computed by the Developer using the following formula and criteria:

\[
Q_d = Q_{pdwf} + I
\]

\(Q_d\) is the design flow in gallons per day

\(Q_{pdwf}\) is the peak dry weather flow in gal. per day

\(I\) is the infiltration and inflow in gallons per day.

The infiltration and inflow component \((I)\) shall be 1,000 gallons/acre/day applied to the gross acreage of the service area.

The peak dry weather flow \((Q_{pdwf})\) for Collection Mains is calculated by multiplying the average dry weather flow \((Q_a)\) based on the factors given in **Table DS 6-1** times a peaking factor of 2.5. This method may also be used to calculate a preliminary \(Q_{pdwf}\) for Trunk Sewers until modeling has been performed.

\[
Q_{pdwf} = Q_a \times 2.5
\]
### Table DS 6-1

**Average Dry Weather Sanitary Sewer Flow Criteria (Qa)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Residential, gpd/du (a)</th>
<th>Schools, gpd/student</th>
<th>Non-Residential, gpd/acre (a)</th>
<th>Non-Residential, gpd/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential – One Bedroom (b)</td>
<td>120</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Residential – Two Bedroom (b)</td>
<td>160</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Residential – Three Bedroom (b)</td>
<td>200</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Residential – Four (or more) Bedroom</td>
<td>240</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Residential (c)</td>
<td>240</td>
<td></td>
<td>1,500</td>
<td>0.115</td>
</tr>
<tr>
<td>Office</td>
<td>–</td>
<td>–</td>
<td>2,000</td>
<td>0.153</td>
</tr>
<tr>
<td>Business Park</td>
<td>–</td>
<td>–</td>
<td>2,000</td>
<td>0.153</td>
</tr>
<tr>
<td>Industrial (d)</td>
<td>–</td>
<td>–</td>
<td>2,000</td>
<td>0.153</td>
</tr>
<tr>
<td>Retail Sales</td>
<td>–</td>
<td>–</td>
<td>1,900</td>
<td>0.145</td>
</tr>
<tr>
<td>Downtown Commercial</td>
<td>–</td>
<td>–</td>
<td>5,000</td>
<td>0.383</td>
</tr>
<tr>
<td>Highway Commercial</td>
<td>–</td>
<td>–</td>
<td>5,000</td>
<td>0.383</td>
</tr>
<tr>
<td>Service Commercial</td>
<td>–</td>
<td>–</td>
<td>1,900</td>
<td>0.145</td>
</tr>
<tr>
<td>Public - Low Water Use</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Public - Medium Water Use</td>
<td>–</td>
<td>–</td>
<td>1,500</td>
<td>0.115</td>
</tr>
<tr>
<td>Public - High Water Use</td>
<td>–</td>
<td>–</td>
<td>1,500</td>
<td>0.115</td>
</tr>
<tr>
<td>Park</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Private Recreation (e)</td>
<td>–</td>
<td>–</td>
<td>1,500</td>
<td>0.115</td>
</tr>
<tr>
<td>Elementary School</td>
<td>–</td>
<td>25</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Secondary School</td>
<td>–</td>
<td>30</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>School Acreage</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Open Space</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hospitals and Medical offices (f)</td>
<td>–</td>
<td>–</td>
<td>4,000</td>
<td>0.306</td>
</tr>
<tr>
<td>Places of Worship</td>
<td>–</td>
<td>–</td>
<td>1900</td>
<td>0.145</td>
</tr>
<tr>
<td>Agriculture</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(a) gpd = gallons per day; du = dwelling unit

(b) Applicable only where the actual allowable dwelling unit and bedroom count is known and subject to no further changes by virtue of an executed development agreement or similar instrument. Where an executed development agreement or approved subdivision map applies to the sewer service area, the number of dwelling units shall be equal to the maximum allowed under such documents.

(c) This factor shall be applied where only an approximate dwelling unit count is available, and for predicted future growth in the service area.

(d) Applies only to dry industries. Design flows for industrial developments with the potential to produce above average flows must be computed on a case-by-case basis.

(e) Factor is not applied to golf course areas of play

(f) Qa shall be based upon project-specific flow projection with a minimum of 4,000 gpd/acre.

**NOTE:** Table DS 6-1 is subject to periodic revisions based upon updated wastewater flow monitoring studies and master planning.
Qa shall be computed as follows:

1. For residential land uses, Qa shall be equal to the appropriate factor from column 2 in Table DS 6-1 multiplied by the number of residential units.

2. For school sites, Qa shall be equal to the appropriate factor from column 3 of Table DS 6-1 multiplied by the anticipated number of students as determined by the Community Development Director.

3. For all other uses, the minimum value of Qa shall be equal to the appropriate factor from column 4 in Table DS 6-1 multiplied by the gross area of development, including roadways, parking, and landscape areas in terms of acres. Where the anticipated uses have the potential to generate higher than typical flows for a given land use category, and where the floor-to-parcel area (FAR) is expected to exceed 0.30, Qa shall be projected on a case-by-case basis using the per-square foot factors in column 5 of Table DS 6-1, or another appropriate method approved by the Director of Public Works.

4. Qa must reflect anticipated actual flows where actual flows are expected to be higher than predicted using the standard factors. In no case shall Qa be less than the minimum value defined in the preceding paragraphs.

C. PIPE SIZE SELECTION: Pipe size shall be selected such that design flow (Qd) is limited to the percentage of full pipe capacity specified in Table DS 6-2. Depth of flow and velocity for gravity flow conditions shall be calculated using Manning’s Equation shown below:

\[ Q = A(1.49/n)R^{2/3} s^{1/2} \]

Where: Q = Flow rate in cubic feet per second, A = The cross sectional area of the flow in the pipe in square feet, n = the roughness coefficient of the pipe and is not less than .013 for all pipe materials, R = Hydraulic radius in feet, and s = slope of the pipe.

D. VERTICAL ALIGNMENT: Unless otherwise authorized by the Director of Public Works, sanitary sewer line grades shall be set as follows:
1. **Minimum Slope:** Minimum slopes and other design criteria for various pipe diameters are shown in Table DS 6-2.

Table DS 6-2. Allowable Utilization of Capacity in New Sewers

<table>
<thead>
<tr>
<th>Pipe Diameter, Inches</th>
<th>Maximum Allowable Utilization of Capacity</th>
<th>Minimum Slope (a), ft/ft</th>
<th>Equivalent Maximum Allowable Flow Qd at Minimum Slope (a), mgd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As Percent of Full Pipe Gravity Flow Capacity</td>
<td>As Depth to Diameter Ratio, d/D</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>70</td>
<td>0.62</td>
<td>0.0035</td>
</tr>
<tr>
<td>10</td>
<td>70</td>
<td>0.62</td>
<td>0.0025</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>0.68</td>
<td>0.0019</td>
</tr>
<tr>
<td>15</td>
<td>80</td>
<td>0.68</td>
<td>0.0015</td>
</tr>
<tr>
<td>18</td>
<td>80</td>
<td>0.68</td>
<td>0.0011</td>
</tr>
<tr>
<td>21</td>
<td>90</td>
<td>0.74</td>
<td>0.0010</td>
</tr>
<tr>
<td>24</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
<tr>
<td>27</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
<tr>
<td>30</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
<tr>
<td>33</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
<tr>
<td>36</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
<tr>
<td>42 &amp; up</td>
<td>90</td>
<td>0.74</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

(a) A slope greater than minimum may be required for Trunk Sewers where the projected flows do not produce the required minimum velocity and/or where higher allowable flows are required. See Section DS 6.02.D.2 for the minimum Trunk Sewer velocity requirements.

2. **Minimum Velocity:** Additionally, the minimum velocity in new Trunk Sewers is two (2) feet per second (fps) at $Q_{pdw}$f. $Q_{pdw}$f is equal to $Q_d$ excluding Infiltration (I). The minimum velocity standard is independent of the minimum slope requirement. Special consideration shall be given in instances where predicted peak flows will not achieve a velocity of two (2) fps for more than the first five (5) years of the life of the pipeline. Steeper slopes, manhole liners, or other modification to these City Standards may be required by the Director of Public Works to prevent odor and corrosion problems where low flows are anticipated.

3. **Maximum Velocity:** A maximum velocity of ten (10) fps is allowed at design flow.
4. **Steep Sewers**: Steep sewers are defined as sewers having a slope greater than or equal to 3%, and shall not be permitted without prior approval by the Director of Public Works. The design submittal for approval by the Director of Public Works shall include the following:

   a. A hydraulic jump analysis shall be performed at the transitions from steep to flatter slopes and special manhole designs shall be provided to accommodate excessive energy dissipation and corrosion control where high velocities occur.

   b. Concrete cut-off walls shall be designed to prevent longitudinal groundwater flow in the pipe bedding material of steep sewers.

   c. Geotechnical soils reports are required where sewers are proposed in hillside developments when the slope exceeds 10%. The report at a minimum shall address the following:

      i. General soils and bedrock conditions and recommended trench, bedding and backfill requirements.

      ii. Stability or instability of selected sewer alignment

      iii. Potential groundwater problems and mitigation measures.

5. **Vertical Curves** – Vertical curves may be allowed if approved by the Director of Public Works when the change in the surface profile grades exceeds 5%.

6. **Change of Direction** – The flow line of the upstream sewer pipe shall be 0.10 feet above the flow line of the downstream pipe at all manholes where a horizontal change of direction of more than 20° occurs.

7. **Change in Size** – Pipe connections solely between Collection Main piping or solely between Trunk Sewer Piping shall be made such that the crown of the smaller main is no lower than the crown of the larger pipe. Connections to Trunk Sewers by a new Collection Main shall be made so that the invert grade of the new main will be no lower than the crown of the Trunk Sewer unless otherwise approved by the Director of Public Works.

8. **Depth** – The depth of any sanitary sewer shall be adequate to obtain a minimum cover of three (3) feet for each service lateral at the flow line of the gutter. Cover in excess of 12 feet must be approved by the Director of Public Works or a parallel more shallow Collection Main system shall be installed in addition to the deep sewer main.

**E. PIPE LAYOUT REQUIREMENTS**: The sanitary sewer system layout shall conform to the Sewer Master Plan and the following requirements:
1. **Trunk Sewer and Collection Main location:** All Trunk sewers and Collection Mains shall be installed within public right-of-ways or, with the approval of the Director of Public Works, in dedicated easements. Where a Trunk Sewer or Collection Main is installed in an easement, the easement shall be 15 feet wide and be located on a single lot with the main centered in the easement. The preferable location for sewer mains shall be six (6) feet from centerline of the street, on the opposite side of the street centerline from the water main. The alignment shall be parallel to the street centerline wherever possible. Where the street centerline is curvilinear in alignment, curved sewer main alignments are preferred and allowed when the deflection at each pipe, coupling, and fitting joint conforms to the criteria specified in Section CS 9 Sanitary Sewer, of the Construction Standards.

2. **Cross-country pipelines:** Cross-country pipelines are defined as pipeline locations located outside of the limits of the public street right-of-way. Cross-country pipelines shall be avoided whenever possible and are only allowed with the approval by the Director of Public Works. If approved, the cross-country pipelines shall be constructed on ground slopes less than 20% with an all-weather access road. The access road shall be provided over the entire length of the cross country pipeline alignment. Where the all weather access road exceeds 10% in grade, the road shall be paved. Paving shall consist of Portland cement concrete or Asphalt Concrete. The pavement structural section shall be approved by the Director of Public Works.

3. **Requirements for Sewer Main Separation from other utilities:**

   Clearances for sewer main installation are illustrated on the “Separation of Water and Sewer Lines” Standard Drawing.

   Any deviation in clearances from the following requirements and the Standard Drawing must conform to the criteria for the separation of water mains and sanitary sewers set forth in the California Water Works Standards contained in the California Administrative Code and must be approved in advance of plan submittal by the Director of Public Works. Additional requirements may be imposed for such deviations.

   Sewer mains shall be installed as follows:

   a. At least ten (10) feet horizontally from and one (1) foot lower than water mains located parallel to the main (measured from the nearest edge of the main).

   b. At least five (5) feet horizontally from all other facilities.

   c. At least one (1) foot lower than water mains crossing the sewer main (measured from the nearest edge of each main). However, a two (2) foot
vertical separation is required between a sanitary sewer force main and a water main.

d. At least nine (9) feet from the water main joints where the sewer crosses the water main.

e. In a separate trench from the water main.

F. ALLOWABLE MAIN LINE PIPE MATERIALS:

1. General: The pipe material used in construction for Sanitary Sewers shall conform to Section CS 9, of these City Standards and the following requirements.

2. Gravity Sewers: The pipe material for sanitary sewers shall conform to the following:

a. The pipe material used in the construction of gravity sewers of eight (8) inch diameter up to and including 12 shall be vitrified clay, ductile iron, or polyvinyl chloride (PVC) SDR26; unless a particular pipe material is specified by the Director of Public Works. Vitrified Clay Pipe (VCP) shall be at a minimum “Extra Strength”. If greater bearing strength is required, “High Strength” VCP shall be specified on the Project Plans.

b. Pipe sizes greater than 12 inches up to 42 inches in diameter shall be Vitrified Clay Pipe (VCP), “High Strength”.

c. Ductile Iron Pipe (DIP) shall be used where inadequate depth, limited separation from other facilities, or other special constraint is present.

d. DIP used in construction of gravity sewer applications shall be lined in accordance with Section CS 9, “Sanitary Sewer Construction Standards”.

e. Mains 42 inches in diameter and greater shall be designed on a case-by-case basis as approved by the Director of Public Works.

3. Force Mains – Force mains (pressure mains) shall be ductile iron with polyethylene encasing. At the sole discretion of the Director of Public Works, PVC per AWWA C 900 (class 150) or High Density Polyethylene (HDPE) with butt-fused joints and wall thickness of not less than DR11 may be considered as an alternative for force mains up to 12 inches in diameter.

a. Thrust restraint shall be provided at all bends and valves as well as at designated lengths of pipe upstream and downstream of each bend or valve to accommodate the thrust restraint requirements. The length of restrained joint pipe shall be calculated using the Ductile Iron Pipe Research Association (DIPRA) Thrust restraint for Ductile Iron Pipe formulas or the EBAA restraint software.
b. The calculations for restraining joints shall be based upon a pressure of 150 percent of the test pressure or 150 psi, whichever is greater. A factor of safety of 1.5 shall be applied to the calculated length to determine the required restrained length. Additionally, the calculations shall include consideration for polyethylene encasement when using DIP.

c. Thrust blocks shall not be used unless approved by the Director of Public Works. Where allowed by the Director of Public Works, thrust blocks shall be installed per Standard Drawings 5-02, 5-03, & 5-04. The dimensions for thrusts blocks for pipe sizes less than eight (8) inches shall be calculated and detailed on the Project Plans.

d. The design for force mains with DIP shall include lining with amine cured quartz filled ceramic epoxy in accordance with Section CS 9, “Sanitary Sewer Construction Standards” for any portion of the pipe that will not always remain full (even with the pump in the off mode). The Design Engineer shall designate the length of pipe on the Project Plans that requires the ceramic lining.

DS 6-03 SANITARY SEWER APPURTEANCES

A. MANHOLES:

1. Manholes shall be located on the sewer main at the following points:
   a. At intervals not to exceed 400 feet.
   b. At changes of pipe size, slope or direction.
   c. At six (6) inch and larger service lateral connections to the main.
   d. At service lateral connection to a 15 inch Trunk Sewer or larger.
   e. At the end of the sewer main.
   f. At transitions between PVC and other pipe materials.

2. Manholes shall be 48-inch inside diameter and conform to the Standard Drawings for pipe sizes 24 inches and less.

3. A specific manhole design shall be included with the Project Plans for pipe diameters larger than 24 inches. The minimum inside diameter for the manhole shall be 60 inches for pipe sizes greater than 24 inches.

4. Hinged frames and covers with locking devices as specified in Section CS 9, “Sanitary Sewer Construction Standards” shall be provided on all manholes located outside the paved area of the public street right-of-way.

5. Cleanouts shall not be used at the ends of sewers unless the sewer is to be extended in the future and the line is less than 200 feet long.
6. Piping for inside drop manholes shall be PVC SDR 26 only.

B. SERVICES:

1. **Slope:** Sewer service laterals shall have a minimum slope of 2% unless otherwise approved by the Director of Public Works.

2. **Location and Alignment:** Sewer service laterals shall conform to the following criteria:
   a. Be at right angles or radial to street right-of-way unless connecting to a manhole.
   b. Be located a minimum of five (5) feet from any driveway or property line.
   c. Be placed a minimum of five (5) feet horizontally from other utility facilities, such as water services, streetlights, storm drains, etc. Clearance from fire hydrants shall be ten (10) feet. In cul-de-sac bulbs, services should enter manholes and should enter at or near the base of the manhole.

3. **Size:** The size of the service shall not exceed the size of the main. The minimum size for single residential units shall be four (4) inches. Minimum size for multi-family residential units, commercial and industrial developments shall be six (6) inches.

4. **Depth:** Sewer service laterals shall have three (3) feet minimum cover at the flow line of the gutter (see Standard Drawing 6-05).

5. **Cleanouts** – Cleanouts shall be installed on all sewer services, and their location shall be within the public right-of-way (see Standard Drawings 6-05 and 6-06).

6. **Connections to Large Mains** – **Four** (4) inch sewer laterals may be directly connected to sewer lines 12 inches in diameter or smaller (per Standard Drawing 6-05). For Trunk Sewers 15 inches in diameter and larger, the sewer service lateral must be connection at a manhole.

7. **Type of Pipe:** PVC SDR 26 or VCP.

C. METERING MANHOLES: Metering Manholes shall be provided in new Trunk Sewers at locations designated by Public Works Utilities Division. Requirements shall be provided by the Director of Public Works on a project-by-project basis.

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**DS 6-04 LIFT STATIONS:** Lift stations shall not be permitted unless specifically approved by the Director of Public Works in advance of the submittal for the Tentative Map or Planning Approval process. Refer to the City’s current Sanitary Sewer Master Plan for lift station design criteria.
DS 6-05 MISCELLANEOUS DESIGN CRITERIA:

A. STUDY MAP: A study map shall be required prior to review of the sewer design if there is a possibility that upstream or adjacent areas might require service through the subject property. The map should show the entire service area including upstream tributary and adjacent areas, and all other data necessary to determine anticipated service area, including pipe sizes and slopes, shall be shown to the extent necessary to determine the mitigations and improvements required within and offsite of the subject property. Any required study map shall be paid for by the project Developer.

B. PROJECT PLANS REQUIREMENTS: The Project Plans shall depict the sanitary sewer in plan and profile views, and typical cross sections. The type and size of pipe material and all appurtenances shall be noted on the plans. The requirements for joint restraints for piping, bends and valves on force mains shall be designated on the plans. The Project Plans shall also show the sewer main crossings with other utilities including vertical clearances; horizontal distances to the roadway centerline, water main and storm drain pipes; flow line of pipe elevations at all grade changes and manholes; service lateral locations, and existing and proposed grades at ground surface. The locations shall be stationed or dimensioned on the plans.

C. EASEMENTS: If public sanitary sewer mains are to be located outside of the public street right-of-way, the sewer main shall be located in an easement of a minimum width of 15 feet. Legal descriptions of the easement shall be submitted with the Project Plans for review and approval by the City prior to approval of the Project Plans.

D. TRENCH LOADING:

1. Minimum Standards for pipe material, trench excavation, and trench bedding, foundation, and backfill are included in the Construction Standards of these City Standard Specifications. However, the Design Engineer responsible for the preparation of the Project Plans shall evaluate the actual site conditions and prepare calculations to ensure that the proposed pipe material, trench width, and the design of bedding and backfill material are adequate based upon the criteria specified below. When certain site conditions and design criteria require a pipe material with greater strength or stiffness, or a trench design, bedding or backfill more stringent than the City minimum standards, these factors shall be included on the Project Plans.

2. Calculations shall be submitted to the City Engineer/Director of Public Works for review and approval for all Trunk Sewer pipe design. Calculations shall also be submitted for Collection Main and Service Lateral piping that do not conform to Table DS 6-3. Table DS 6-3 shows the maximum depth of the various Collection Main and Service Lateral pipe material using Crushed Rock bedding as defined in these City Standard Specifications. If the design
conditions do not conform to criteria used to establish the maximum cover shown in Table DS 6-3, then calculations shall be submitted to the Director of Public Works/City Engineer for review and approval.

Table DS 6-3

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Pipe Material</th>
<th>Maximum Cover Over Top of Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 8 inch</td>
<td>Extra Strength VCP(^1)</td>
<td>20 feet</td>
</tr>
<tr>
<td>4 to 8 inch</td>
<td>High Strength VCP(^1)</td>
<td>20 feet</td>
</tr>
<tr>
<td>10 inch</td>
<td>Extra Strength VCP(^1)</td>
<td>18 feet</td>
</tr>
<tr>
<td>10 inch</td>
<td>High Strength VCP(^1)</td>
<td>19 feet</td>
</tr>
<tr>
<td>4 thru 10 inch</td>
<td>PVC SDR 26(^2)</td>
<td>20 feet</td>
</tr>
<tr>
<td>4 thru 10 inch</td>
<td>DIP(^3)</td>
<td>20 feet</td>
</tr>
</tbody>
</table>

\(^1\)The maximum cover over the pipe was calculated using Marston’s Formula in accordance with the ASCE Manual of Engineering Practice No. 60/WPCF Manual of Practice No. FD-5, backfill weighing 140 lbs per cubic foot, H-20 loading, trench load calculated using “transition width”, a load factor of 2.2, a \(r_{dp}\) factor of 0.75, and a Factor of Safety of 1.25.

\(^2\)The maximum cover over the pipe was calculated using the Modified Iowa Formula in accordance with the ASCE Manual of Engineering Practice No. 60/WPCF Manual of Practice No. FD-5, backfill weighing 140 lbs per cubic foot, H-20 loading, trench load calculated using “prism load”, a Deflection Lag (\(D_L\)) factor of 1.0, a bedding constant (\(K_b\)) factor of 0.1, the modulus of soil reaction (\(E'\)) for Crushed Rock bedding equal to 1000 lb/in\(^2\), the modulus of tensile elasticity (\(E\)) of the PVC pipe equal to 400,000 lb/in\(^2\), the maximum calculated deflection of the PVC pipe equal to 3-1/3\% (with a Factor of Safety of 1.5) to achieve an in place maximum deflection of 5%.

\(^3\)The maximum cover over the pipe was calculated using the latest revision of American Water Works Association/American National Standards Institute C-150/A21.50 – Thickness Design of Ductile Iron Pipe and AWWA Manual M-41 – Ductile Iron Pipe and Fittings, backfill weighing 140 lbs per cubic foot, H-20 loading, trench load calculated using “prism load”, the maximum in place deflection of the pipe equal to 3\% (unless flexible lining is used where the maximum deflection is 5\%), and a Factor of Safety of 1.5.

3. VCP Pipe Calculations: Marston’s formula shall be used to determine the load placed on the pipe by the backfill. The design procedure for this pipe material shall be in accordance with the ASCE Manual of Engineering Practice No. 60 / WPCF Manual FD-5, “Gravity Sanitary Design and Construction”, and the Clay Pipe Engineering Manual. The following criteria shall apply when calculating the loads on VCP pipe:

a. The pipe and trench design for Collection Main and Service Lateral pipe shall be calculated using the Transition Width. The pipe and trench design
for Trunk Sewer pipe may be designed at Transition Width. The calculated safety factor shall be a minimum of 1.25 when the trench load is calculated at Transition Width.

b. The calculated safety factor shall be a minimum of 1.5 when using specific trench width design maximums that are less than Transition Width for Trunk Sewer pipe and trench design. The maximum trench width is controlled by the ability of the pipe and bedding to resist the vertical external load and shall be subject to the approval of the City Engineer/Director of Public Works and the maximum trench width shall be clearly designated on the Project Plans with notations of the requirements if the maximum width is exceeded in construction.

c. When using Crushed Rock for bedding, a maximum load factor of 2.2 shall be utilized to calculate the allowable load.

d. The earth load (dead load) shall be calculated based upon the conservative prism load condition (also referred to as “transition width” or embankment condition) unless maximum trench widths are specified on the Project Plans in accordance with “b” above. A minimum soil weight of 140 pounds per cubic foot shall be assumed for trenches unless geotechnical soils report data can substantiate other values.

e. All pipes with less than nine (9) feet of cover (including areas not intended for vehicular traffic) shall be designed with AASHTO H-20 truck loading.

4. PVC Pipe Calculations: The method for calculating loads and determining the design requirements for PVC sewer pipe shall be in accordance with the latest published edition of ASCE Manual and Report of Engineering Practice No. 60 / WPCF Manual FD-5, “Gravity Sanitary Sewer Design and Construction.” The Modified Iowa Formula shall be used to estimate the deflection of the pipe under load conditions. The following factors shall be taken into account for calculating the design loads and deflection:

a. The assumed modulus of soil reaction (E’) used in the deflection calculation shall be 1000 psi, for Crushed Rock bedding. The Deflection Lag factor (D_L) shall be assumed as 1.0 and the Bedding Constant (K) as 0.1. The modulus of elasticity (E) of the PVC pipe shall be assumed to be 400,000 psi.

b. The earth load (dead load) shall be calculated based upon the conservative prism load condition. A minimum soil weight of 140 pounds per cubic foot shall be assumed for trenches unless geotechnical soils report data can substantiate other values.

c. All pipes with less than nine (9) feet of cover (including areas not intended for vehicular traffic) shall be designed with AASHTO H-20 truck loading.
d. For installation, the maximum allowable deflection shall be 5.0 percent of the pipe’s “Average Inside Diameter” as defined by ASTM 3034 when measured not less than 30 days following completion of the trench backfill. For design purposes, a safety factor of 1.5 shall be assumed. Therefore, the calculated deflection shall not be more than 3-1/3 percent.

5. **DIP Calculations:** The Thickness Design of DIP is based on the flexible conduit theory. Earth load is based on the conservative Prism design theory. Truck loading is based on AASHTO (American Association of State Highway and Transportation Officials) H-20 Truck loading (16,000 lb wheel load.) Specific formulas and methods for determining appropriate design thickness shall be in accordance with the latest revision of American Water Works Association/American National Standards Institute C-150/A21.50 – Thickness Design of Ductile Iron Pipe and AWWA Manual M-41 – Ductile Iron Pipe and Fittings.

E. **BEDDING AND INITIAL BACKFILL:** Bedding and initial backfill type shall be as necessitated by height of cover over the pipe, trench width, pipe strength, and other factors used to determine safe pipe loading. Any special backfill requirements shall be noted on the plans. The minimum design for bedding and backfill shall conform to Standard Drawings and Section CS 3 Trench Bedding and Backfill of the Construction Standards contained in the City Standard Specifications.